COOLING COWS IN THE TRANSITION PHASE

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Summer depression of production causes significant economic loss in the dairy industry. Heat stress occurs from solar radiation, high ambient air temperatures, and high relative humidity. This is further aggravated by heat production from the cow's own body. Generally, the higher producing the cow, the greater the heat load produced from digestion and metabolism. Responses to heat stress include panting and sweating. If these are not successful in alleviating the heat load, body temperature will rise. Increased body temperature will result in reduced feed intake, higher maintenance requirement (panting can increase this as much as 25%), decreased fertility, depressed immune system function, lowered growth and milk production and less efficient productive ability. The higher maintenance requirement dictates that cows need to increase feed intake to maintain milk production. However, this is not possible as feed intake declines when ambient temperatures exceed 78°F. As a result of this increase in requirement and decrease in intake, milk production may decline as much as 30%, percentage of milk components may shift, and reproduction efficiency declines.

Adjustments in both nutrition and management during the summer months can help the cow in lessening her heat load. Nutrition alterations may include adjusting bunk management and feeding schedules, increasing energy density in the ration, and use of feed additives (buffers, potassium carbonate, yeast, etc.). Management considerations include cooling systems. While much of the diet adjustment is made with a nutritional consultant, it is typically the dairy producer who decides on the cooling system.

The objective of any cooling system is to keep the cow's body temperature as close to normal for as much of the day as possible. An acceptable range in rectal temperature is 101.3-102.8°F. The most common approaches include shades (to intercept solar radiation) and fans/sprinklers (evaporative cooling). The easiest and most obvious way to help heat-stressed cows is to provide shade. Direct sunlight adds a tremendous heat load to the cow and can be blocked by either permanent or temporary shades. The second step would be to provide additional cooling in the form of fans and sprinklers. Sprinkling the cow with water to fully wet her body and using fans to evaporate the water cools the cow and encourages greater feed intake and milk production.

Research has demonstrated the production responses of the lactating cow to cooling, showing an 11% increase in milk yield when cows were supplied with additional cooling (by fans and sprinklers) under shade versus shading alone. Yet, while carry-over effects of nutrition management in the transition phase on post-partum production have been well established, little work has been done in defining the responses of cooling cows in this period. The significance of the transition phase to lactation performance has been recently reviewed by Drackley (1999). For the purpose of this paper, the transition phase will include both the dry period and the first 15-30 days into lactation.

THE DRY COW

The dry period is particularly crucial since it involves mammary gland involution and subsequent development, rapid fetal growth, and the induction of lactation. Physiological, dietary, and environmental changes during this time have a critical influence on postpartum cow health, nutrient utilization, and milk production. Additionally, this is also when follicular development and maturation is being initiated for the following reproductive cycle. The metabolic heat load of the dry cow is approximately one-half of that of a lactating cow producing 65 pounds of milk. While this is low relative to her heat dissipation capacity of the animal, it's thought that the endocrine system is more sensitive to moderate heat stress during the dry period than during lactation.

Prepartum endocrine responses due to prepartum heat stress may include reduced concentrations of both plasma T4 and placental estrogen and increased NEFA level (Collier et al., 1982). A reduction in T4 concentrations by heat stress during pregnancy could affect growth of maternal tissues (mammary gland, placental, or fetal tissue). Additionally, it may influence postpartum mammary function, since mammary development and lactogenesis have been shown to be greatly influenced by thyroid hormones. A reduction in placental estrogen may also have effects on mammary growth and postpartum milk yield. The cause of elevated NEFA in heat stressed animals is not clear; however, elevated NEFA may be related to altered endocrine or metabolic status of heat stressed animals or due reduced energy intake.

Lewis et al. (1984) suggested prepartum heat stress had residual effects on postpartum PGFM concentrations and rate of uterine involution. This study reported no effect of prepartum heat stress on days to first estrus, days open, or services per conception. Wiersma and Armstrong (1988) suggest the primary benefit from prepartum cooling may be a reduction in number of cows culled open after 10 months of lactation.

The effects of shade and cooling for heat stress relief during the last trimester of pregnancy consistently report increased calf birth weights. Studies show an increase in birth weights (as much as 10%) in calves born to cows cooled prepartum. Collier et al. (1982) reported a direct relationship between calf birth weight and subsequent milk production, suggesting those factors associated with calf birth weight also influence postpartum milk yield. This is in agreement with estimates from large herd data sets.

Other effects of heat stress during the dry period may include reduced colostrum quality. Nardone et al. (1997) reported lower immunoglobulin content (IgG and IgA) and reduced levels of total protein, fat, and lactose in the colostrum of heifers exposed to heat stress prepartum. Research reports that calves born during the summer suck their dams less vigorously and may have impaired absorption efficiency caused by heat stress. Lower absorption efficiency, coupled with the lowered content of colostrum, may increase the incidence of health complications and mortality in calves born during the summer and early fall.

Milk production responses to prepartum cooling on post-partum production have been variable. Wiersma and Armstrong (1988) and Collier et al. (1981, 1982) found no significant differences in milk production due to prepartum cooling (either as shades or evaporative cooling systems), although there was a trend in both trials for slightly higher milk production in cows cooled prepartum compared to noncooled cows. Wolfenson et al. (1988) reported prepartum evaporative cooling negatively affected first month milk yield in cows calving in early summer. In these cows, the first month of lactation occurred during hotter months (07/01-09/15) than for those calving in later months (09/15-11/30). Average temperatures for these periods averaged 88/77 ^{o}F and 79/55 ^{o}F (maximum/minimum temperatures for 07/01-09/15 and 09/15–11/30, respectively). These researchers suggested that prepartum cooling *might* temporarily reduce adaptation to summer heat postpartum. However, this trial also reported prepartum cooling increased 150-day milk production by 8 pounds per day as compared to the noncooled group. Research from Mississippi State University (Moore et al., 1992) evaluated 341 lactations from six sites through DHI records and reported heat stress in the early dry period (60 days prepartum) had the greatest negative influence on milk production in early and midlactation. Heat stress in this trial was defined as the total number of degrees that the maximum temperature exceeded 90^{o}F.

THE FRESH COW

This is the period of time when the cow is most susceptible to infectious diseases and metabolic disorders. Several groups have estimated the cost (lost milk production and treatment expense) of health disorders during this period. Perhaps the biggest challenge in managing the fresh cow is getting her on feed the first few weeks postpartum. A strong and steady increase in feed intake supports high production while minimizing the depletion of body stores. The rate of increase in feed intake postpartum is a primary factor dictating energy intake and balance. Nocek (1997) suggests intake at 5 weeks postpartum should be 50% greater than intake during the first week.

Despite the relationship of cow health and performance in early lactation to total lactation performance, little work has directly evaluated the response of cooling fresh cows. Research demonstrating milk yield responses to cooling commonly involve cows greater than 60 days in milk. Work in Central Texas reported increased peak milk yield and earlier days to peak production (Stokes and Pope, 1997) of fresh cows housed with evaporative cooling compared to noncooled cows. Likewise, cooled cows were able to sustain continuous higher levels of milk production than noncooled control cows.

Heat stress in cows prior to breeding and during early pregnancy can affect fertility. Wolfenson et al. (1988) reported an increase in both conception rate (59 vs 17%) and 90-day pregnancy rate (44 vs 14%) of cooled cows compared to noncooled cows. Additionally, estrous behavior lasted longer in cooled (16 hours) than noncooled (11.5 hours) cows having low body condition scores (average 2.6). Dunlap and Vincent (1971) reported heifers exposed to heat stress the first 72 hours after AI did not conceive at all.

SUMMARY

Prepartum heat stress may affect postpartum production (calving performance, milk yield, and reproduction). Research reports consistent responses in rectal temperature, respiration rate, and calf birth weight to prepartum cooling. Responses in postpartum milk production and reproductive measures have been variable and are less defined.

Defining the response to prepartum cooling is difficult because research in this area is not consistent in methodology or variables measured. Duration and extent of prepartum cooling between trials varied, making comparisons across reports difficult. Few trials measured total performance (both milk yield and reproductive efficiency). Responses to prepartum heat stress are listed in Table 1.

Table 1. Effects of prepartum heat stress on physiological and productive variables.

Variable	Response
Rectal temperature	Increased
Respiration rate	Increased
Serum cortisol level	Increased
Plasma thyroxine level	Decreased
Calf birth weight	Decreased
Colostrum quality (IgG, IgA level)	Decreased
Postpartum milk production	Variable
Services per conception	Variable

Heat stress in the fresh cow may impair health, decrease milk yield, and lengthen time to peak milk production and peak feed intake. Few trials have been done to evaluate fresh cow response specifically, but research done on later lactating cows may be more applicable to responses in this group.

CONCLUSIONS

Several trials reporting little or no response to prepartum cooling suggested the lack of responses were due to limited duration (last 15 days of dry period). Some of the studies evaluated herd records in different seasons as a reflection of heat stress. While most producers recognize the performance differences in cows calving during periods of heat compared to those calving in cooler periods of the year, factors such as day length, humidity, and other environmental effects may also contribute to these responses.

The effects of heat stress may be more pronounced in older cows than first-lactation heifers. Thompson et al. (1999) reported a significant reduction in 305-day milk production of second-lactation or older cows that was not seen in first-lactation heifers. It is a common field observation that heifers don't suffer heat stress to the extents that mature cows do. This may be supported by field observations of heifers eating during the hottest part of the day when their mature herdmates do not. However, heifers raised in cooler climates and then transported south during periods of summer heat may be less able to acclimate.

Variations in postpartum performance response bring question to the economics of prepartum cooling. While some measures provide impartial economic analysis (milk production, calf birth weight, and health treatment), other effects of cooling (body condition, endocrine status, and reproductive profile) are not as easily documented. Cost:benefit analyses of cooling systems, at any stage of production, need to consider both immediate and long-term effects on production. However, current research data does not clearly define long-term benefits and more trials are needed to determine the economics of prepartum cooling management.

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