Impact of Dry Cow Cooling on Subsequent Performance and Health

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Introduction

Heat stress has profound negative effects in lactating cows, and some of that response is due to depressed dry matter intake (Collier et al., 2006). Recent evidence suggests that other physiological insults related to the heat are responsible for the remaining negative effects on yield, which indicates that alternate coping mechanisms are active in the cow that may affect other production endpoints (Wheelock et al., 2010). Therefore it is perhaps not surprising that lactating cows are adversely affected beyond simply reducing intake, as heat stress compromises reproductive performance and various health outcomes in addition to the lower yields (Collier et al., 2006).

Dry cows typically consume much lower amounts of dry matter relative to lactating cows, and thus are able to cope with heat stress more effectively than those producing milk. But despite the lower DMI, heat stress of dry cows has significant negative impacts on yield in the subsequent lactation, and those effects persist throughout lactation (Wolfenson et al., 1988). We have recently shown that heat stressed dry cows also experience reduced immune function and are at higher risk for disease compared with cows that are cooled when dry (do Amaral et al., 2010; 2011). This paper describes the impact of heat stress during the dry period on various aspects of performance and health as cows transition into lactation, and provides some considerations for management interventions that are useful to overcome effects of heat stress.

Milk Yield and Mammary Growth

Early studies to address the effects of heat stress on dry cows focused on providing shade to animals as a heat abatement strategy. Collier et al. (1982) observed that simply shading cows reduced body temperatures relative to cows without shade, and lower rectal temperatures were associated with heavier calf birth weights, longer gestation length, and suggested that milk yield would be improved with that approach. The next step was the use of active cooling approaches, including fans and soakers to more effectively reduce heat load versus shade alone, to improve the performance in the next lactation. Wolfenson et al. (1988) showed that cooling dry cows increased the birth weights of calves and improved milk yield 3.6 kg/d during the first 150 DIM. Thus, active cooling during the dry period dramatically increases yield in the subsequent lactation. There is, however, a duration effect, as other studies indicate that cows cooled for only the final portion of the dry period had a lower milk response relative to studies that cool cows the entire dry period (Urdaz et al., 2006).

We have recently completed a series of studies that confirm the positive impact of heat stress abatement in the dry period on performance in the next lactation (do Amaral et al., 2009; 2011; Tao et al., 2011; 2012; Thompson et al., 2012). The approach we used was to provide shade to all cows by housing them in a free stall barn for the entire dry period. The cooled cows had access to feed-line soakers and fans over the freestalls, whereas the heat stressed group had only shade. Figure 1 illustrates the typical milk yield response of cows that are cooled when dry (Tao et al., 2011). The consistency of the milk yield response across 5 experiments is striking, with persistent increases in yield of 3.5 kg/d for the entire lactation. It is clear that dry cows that are cooled produce more milk in the next lactation, but the question becomes what is the underlying physiology that causes the response?

In any situation, milk yield is a function of the number of mammary cells and the relative metabolic activity of those cells. Although an increase in either cell number or activity can increase yield, an increase in cell number would be expected to cause persistent increments whereas an effect on metabolism may more transient. Using a serial mammary biopsy technique we collected mammary samples from cows during the dry period and into early lactation; cows were cooled or heat stressed when dry (Tao et al., 2011). Relative to heat stressed cows, we observed an increase in the proliferation of mammary cells in cooled cows during the transition, which indicates greater capacity for milk synthesis. Another factor that influences total mammary cell number is the rate of loss of cells, or apoptosis. There was no difference in the rate of apoptosis between heat stressed and cooled cows. Therefore, cooled cows have a greater net gain in secretory capacity during the dry period, and that is expressed as higher milk yield in lactation.

Dry Matter Intake and Metabolism

As in lactating cows, dry cows under heat stress will reduce dry matter intake (Figure 2; Tao et al., 2011; 2012). The reduction in intake is evident very soon after heat stress is applied, and remains for as long as the cow is heat stressed. We observed that bodyweight and body condition score increases follow cooling of dry cows, but cooled cows lose a greater share of bodyweight and condition post-partum, likely as a function of the greater milk yields associated with prepartum cooling (Tao et al., 2011; 2012).

In contrast to intake, there is no evidence that dry period heat stress alters the physiological control of nutrient metabolism (Tao et al., 2012). For example, basal concentrations of insulin were not different in heat stressed vs. cooled cows when they were dry, but differences did manifest during lactation. Circulating NEFA concentrations were also not different in cooled and heat stressed cows during the dry period. However, cows cooled when dry did lose more weight and body condition post-partum relative to heat stressed cows once lactation began, though this was likely a result of much greater milk yield.

Immune Status and Health

Our previous work with another environmental factor that affects performance and health of dry cows, namely short day photoperiod, provides evidence that altered prolactin signaling drives many of the observed effects on milk yield and immune status (Dahl et al., 2012). Specifically, decreases in light exposure, i.e. short day photoperiod, reduces circulating prolactin concentrations relative to a long day (Figure 3). However, prolactin receptor expression at various tissues including the mammary gland and immune cells increases, thereby enhancing the responsiveness of those tissues. Because cooling cows causes a similar reduction in prolactin to that shown for short days, we hypothesized that cooling dry cows would increase immune function and improve health during the transition (Dahl, 2008).

There are two primary arms to the immune system. Innate immunity is the non-specific response to a pathogen or other non-self molecule, whereas acquired immunity is a specific antibody generated response. We compared various aspects of both arms of the system in dry cows cooled or exposed to heat stress. Cows that were actively cooled during the dry period had lower circulating prolactin compared with heat stressed cows, and the lymphocyte expression of prolactin receptor was increased (do Amaral et al., 2010). Those same cooled cows had greater lymphocyte proliferation versus the heat stressed animals, an indication of improved immune status. Cooling also increased the capacity for neutrophils to destroy bacteria through the process of oxidative burst generation (do Amaral et al., 2011). Thus, cooling dry cows improved the ability to resist infection in early lactation.

With regard to acquired immune function, we examined the cow's ability to generate antibodies to a specific non-self protein, i.e. ovalbumin (do Amaral et al., 2011). Cows were injected with ovalbumin early in the dry period and then received boosters of ovalbumin through the dry period and into lactation. Of interest, cooled cows had greater ovalbumin IgG responses relative to heat stressed cows, but that effect was evident only during the dry period (Figure 4). So it appears that the two arms of the immune system act differently in response to environmental factors. That is, the acquired immune function appears to be influenced during the dry period, whereas the innate system is affected during the initial stages of the next lactation. In both cases, however, improvements in immune status would result from cooling of dry cows.

Conclusions

Based on previous studies and our recent work, there is compelling evidence that cooling dry cows improves milk yield in the next lactation. In addition, those cows that are cooled are better able to navigate the metabolic challenges of early lactation, and have improved immune status at a time of significant risk for disease. The approach to cooling is the same as that for lactating cows but should be implemented as early in the dry period as possible to maximize the benefits to the cow as she transitions into lactation.

References

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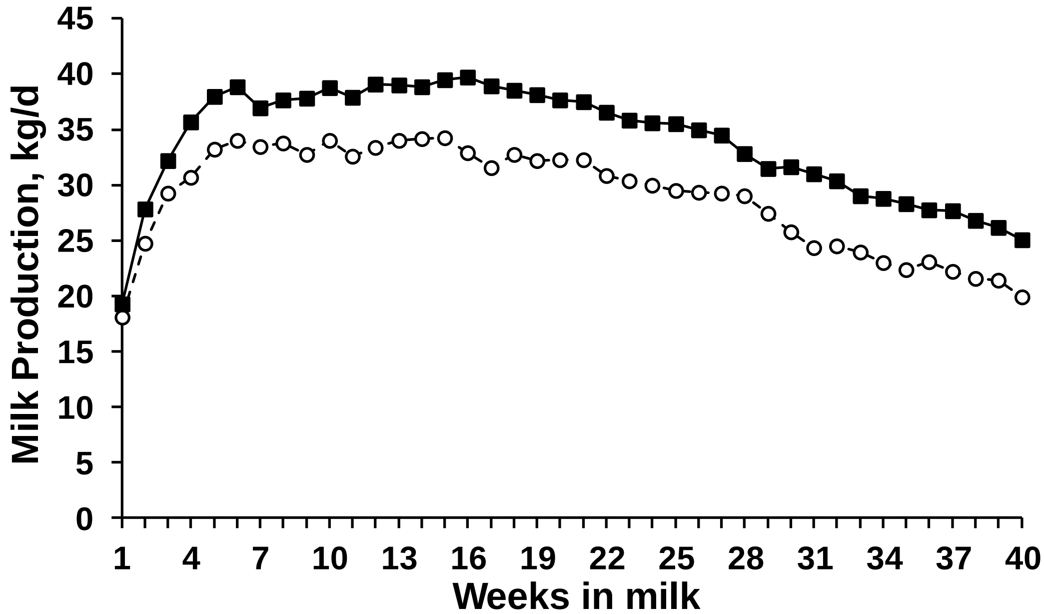

Figure 1. Milk yield of cows exposed to heat stress or cooled during the dry period. Dry period cooling increased yield relative to heat stress. Cows were managed identically, including cooling, during lactation. Redrawn from Tao et al., 2011.

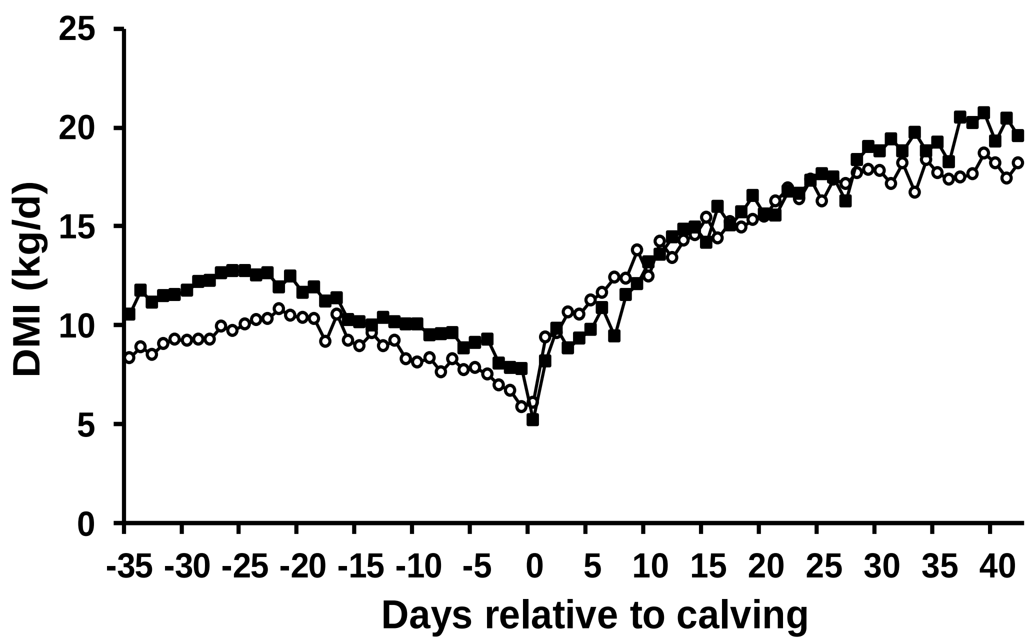

Figure 2. Dry matter intake of cows exposed to heat stress or cooled during the dry period. Dry period cooling increased DMI relative to heat stress prepartum. Cows were managed identically, including cooling, during lactation. Redrawn from Tao et al.. 2011.

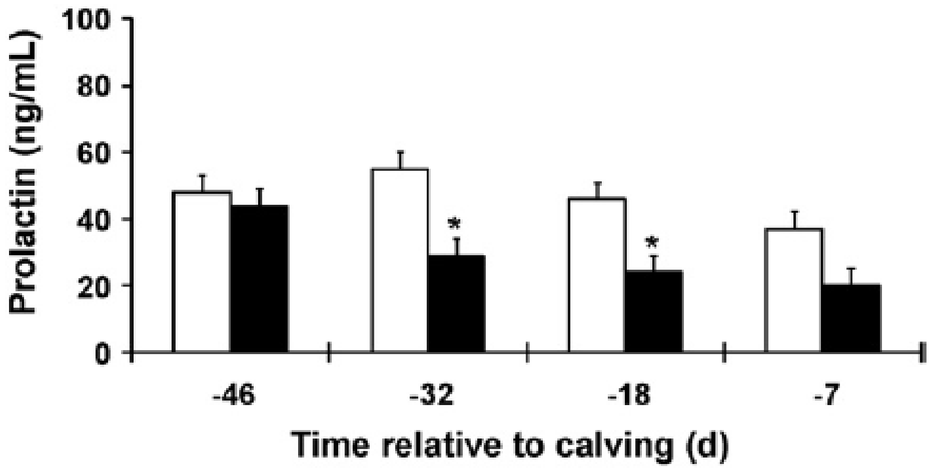

Figure 3. Circulating prolactin concentrations of cows exposed to heat stress or cooled during the dry period. Dry period cooling decreased prolactin relative to heat stress prepartum. Cows were managed identically, including cooling, during lactation. Redrawn from do Amaral et al., 2010. *P<.05.

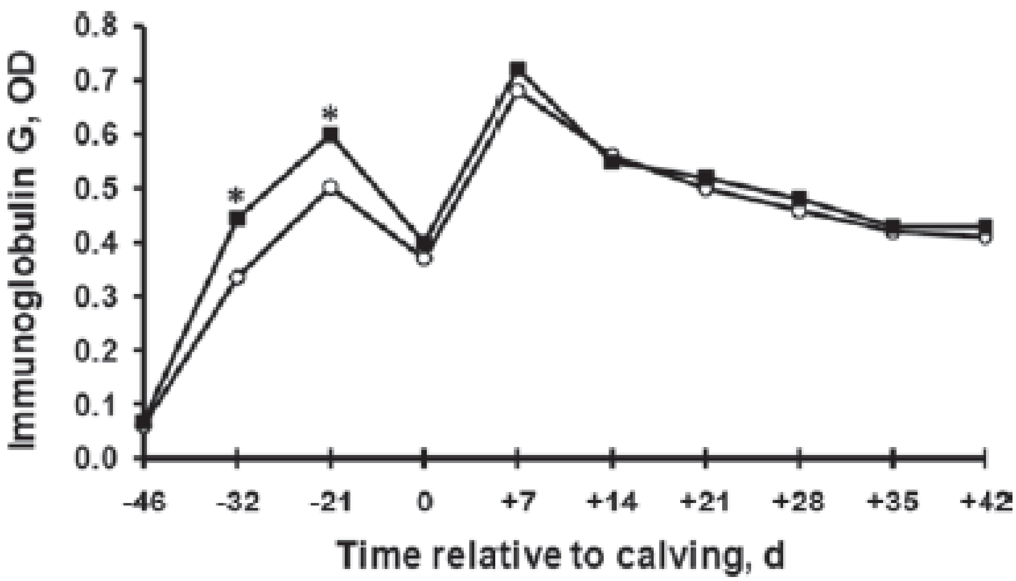

Figure 4. Concentrations of IgG from cows exposed to heat stress or cooled during the dry period in response to an ovalbumin challenge. Dry period cooling increased ovalbumin IgG relative to heat stress prepartum. Cows were managed identically, including cooling, during lactation. Redrawn from do Amaral et al., 2010. *P<.05.

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