Heat stress effects on the dry cow and her calf; evidence to support cooling cows throughout the lactation cycle.

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As ambient temperatures continue to rise globally and warm weather extends for more of the year, impacts of heat stress on the dairy cow become a greater threat to health and productivity. Historically, heat stress abatement has been focused on the lactating cow with good reason. Heat stress during lactation reduces milk yield, alters composition, lowers dry matter intake and adversely impacts health and reproduction. While sub-tropical areas such as the southeastern US are subject to heat stress much of the year, heat stress is often ignored in more temperate regions, yet those locations can experience significant periods of high temperature and humidity in the summer. Heat abatement involves actively cooling cows, usually through application of water via soakers and air movement using fans to dry the hide and remove heat as the water evaporates. A focus on the productive portion of the herd is logical, but there is increasing evidence that ignoring heat stress of the dry cow will lead to negative outcomes on productivity, health and even the offspring of those cows.

We have now completed extensive studies examining the impact of dry period cooling on various aspects of productivity and health. The basic design for those studies involves housing the animals in typical sand-bedded freestall barn with water soakers over the feed bunks. Those soakers cycle on automatically when temperatures exceed 70 ^{o}F for 1 min and off for 4 minutes. Fans, which come on at 72 ^{o}F, are placed over the stalls provide air movement to promote evaporation of the water from the cows backs and sides, thus cooling the animals effectively even in a humid environment. This active cooling system allows cows to maintain a constant body temperature and avoid heat stress. To initiate our heat stress treatment we simply shut off the fans and soakers to those groups of animals. Core body temperature increases by 0.8 to 1.2 ^{o}F in the absence of cooling, and that increment is maintained for the entire dry period in our study model. All cows are cooled after parturition, and all other management is the same before and after the dry period except for cooling.

Using this system we have answered a number of questions related to the impact of dry period heat stress on production and health. For example, heat stressed dry cows consume less feed than cooled herdmates, and they calve 3-4 days earlier. Both of these observations suggest a significant negative impact of heat stress on metabolism and placental function, which may explain the observed lower yield in the next lactation. However, metabolic variables such as circulating insulin, glucose and free fatty acid concentrations do not differ between cooled and heat stressed dry cows despite a 10% reduction in dry matter intake. Mammary growth is lower in heat stressed dry cows, likely as a result of altered endocrine status and the reduction in total gestation length and thus duration of mammary regeneration. Although the lower DMI with dry period heat stress partially explains the poorer performance in the next lactation, the physiological impacts on placental function and mammary growth are the primary factors in lower yield.

Late gestation heat stress also alters immune status of cows both directly in the dry period and indirectly during the next lactation. Cooled dry cows have greater leukocyte proliferation relative to heat stressed dry cows, and the antibody response to an antigen is lower in cows that are heat stressed when dry. These results indicate that heat stress has a direct, depressive effect on immune status relative to active cooling. After calving, despite being actively cooled, cows that were heat stressed when dry have lower innate immunity ass indicated by lower circulating neutrophil concentrations in early lactation and altered neutrophil gene expression consistent with poorer ability to detect and eliminate pathogens. In fact, cows that were heat stressed when dry had lower phagocytic action and oxidative burst capacity than cooled dry cows, even though the heat stress ended at calving. Collectively these observations support the idea that immune status is improved with dry period cooling.

Given the results summarized above, other questions arise with regard to actual application of dry period cooling. For example, do cows require cooling for the entire dry period? Do late gestation heifers, about to calve for the first time, require cooling? Does dry period cooling improve disease and other performance indicators such as reproduction? In a recent study we cooled cows for the initial half of the dry period, the second half, or the entire dry period and compared their productivity to a group that were heat stressed the entire dry period. Compared with cooling the entire dry period, cows that were heat stressed in the first or second half of the dry period had lower yields in the next lactation, essentially the same as cows that were heat stressed for the entire dry period. Our interpretation of those results is that any heat stress during late gestation is detrimental to future productivity. As for late gestation heifers, we compared cooling for the final 60 days of pregnancy to heat stress, and found that the cooled heifers made more milk in their first lactation than the heifers that were heat stressed, similar to reposes observed in older cows. Finally, in a field study we compared records of cows that were dry in the summer with those dry in the winter months on a large commercial dairy in Florida. Cows that were dry in the summer had greater incidence of mastitis, retained placenta and respiratory disease, and made less milk than herdmates dry in the winter. Cows dry in the summer also took 5 days longer to become pregnant relative to winter dry cows, indicating that being cool when dry improves health and reproductive performance as well as milk yield.

Heat stress in late gestation profoundly influences the cow, but also has significant negative implications for the developing fetus, both early in life and at maturity. Calves born to cows that are heat stressed are born at lower weights, wean at lighter weights, and have poorer passive transfer from colostrum than those born to cooled dams. The drag on growth persists through puberty as calves heat stressed in utero are lighter and shorter at 1 year of age. They also tend to leave the herd sooner than their herdmates from cooled dams. Ultimately, the calves from heat stressed dams produce less milk in their first lactation and that reduced productivity extends to their second and third lactation as well. Heat stress in utero causes fetal programming impacts beyond the lower productivity described above. The calves born to heat stressed dams have reduced survival when compared to calves from cooled dams; cooled calves are in the herd an extra 350 days versus the heat stressed calves. And the heat stressed calves pass along the poorer performance to their offspring, with their calves being less likely to remain in the herd than those from cooled dams.

If these limitations on productivity and health were carried through at the herd level, one might expect an effect of birth season on longevity and performance, and indeed that occurs. We analyzed records from commercial herds in Florida and California across multiple years, and identified cows that remained in the herd for five or more lactations. A clear pattern emerged to indicate that heifers born in the cooler months of the year had a greater likelihood to survive to the 5th lactation or beyond. When the reasons cows left the herd were examined it was also clear that the normal issues of mastitis, reproductive competence and feet and leg problems explained the exit of cows across the board; it's just that those problems occurred more frequently in the animals born in the summer versus the winter and led to shorter herd lifespan.

Our most recent efforts have focused on the impact of heat stress on placental function under heat stress, as that organ is the nexus for effects on the dam and developing fetus. Whereas the primary function of the placenta is to provide nutrients and gas exchange from the maternal side to the fetus, it also serves as to exchange heat with the fetus and the dam and as a source of hormones that impact the dam, particularly those associated with mammary development in late gestation. Concentrations of progesterone and estrogens are reduced with heat stress in late gestation, as are other pregnancy specific hormones that may affect mammary growth. Another hallmark of placental dysfunction is apparent at calving, as the number of placentomes (as indicated by cotyledon number) are reduced by half with heat stress relative to cooling. These structural changes in the placentas of heat stressed dams likely limit the capacity for nutrient and gas exchange, and along with the shorter time in utero for calves from those heat stressed mothers may drive the lower growth observed at birth and beyond.

The studies described in this paper strongly support the idea that dry cows require cooling, for the entire dry period, in order to maximize performance and health in the next lactation. We have estimated that lack of cooling of dry cows costs the US dairy industry approximately USD$ 800 million annually when only the effects on the cows are considered. A more recent study included the effects of in utero heat stress on calf loss and decreased survival and that increases the estimated losses to over USD$ 1 billion annually. Therefore, the effects of heat stress in late gestation need to be considered and managed to improve the health and performance of the cow and calf, which should realize a significant improvement in the financial status of the farm as well.

Additional resources:

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