Seasonal Effects on Immunity of Dairy Calves

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Introduction

Domestic animals remain at peak production only if they are housed in a clean, dry and comfortable environment thereby decreasing susceptibility to infectious diseases. Many animals, however, are unavoidably subjected to environmental stresses such as rapid ambient temperature fluctuations, adverse weather, and metabolic shifts due to changes in quality and quantity of food. Recent research indicates that temperature fluctuations can cause alterations in the cells of the immune system of young calves and that these alterations may influence susceptibility to disease. Research also shows that temperature affects the quality of colostrum generated by the dam, again influencing disease resistance in calves. The long-term goals of this research are to gain a greater understanding of responses of the bovine immune system to temperature fluctuations and to investigate potential mechanisms for host-environment interactions that compromise disease resistance. This research will hopefully lead to development of more effective vaccination strategies, a decreased reliance on antibiotics in animal agriculture, and provide improved management practices.

The First 24 Hours

Calves must obtain immunity from colostrum for survival. Colostrum provides maternal immunoglobulins (Ig) specific for vaccinations or local diseases to which the cow has been exposed. In cattle this transfer of Ig mainly occurs through the colostrum. Therefore the first 24 hours becomes a critical juncture for the calf's immune system. Without these Ig the calf's immune system is too immature to mount a successful response to a disease challenge.

A study was conducted to evaluate immune parameters of cows prior to and at parturition and subsequent immunity of their calves. Although immunoglobulin (Ig) G_2 was the predominant type of Ig present in serum of the cows, the IgG_1 type decreased in the serum of the cows prior to calving and was the predominant Ig in colostrum. Further, the research showed that the concentrations of total Ig in colostrum were greater in winter compared with summer. In calves, concentrations of Ig also were greatest in winter reflecting the greater concentrations of Ig in colostrum in winter as compared to summer. Not surprising, the predominant isotype in calf serum was IgG_1, reflecting absorption of the predominant Ig from colostrum. In a separate study, scours incidence and severity were significantly decreased in winter as compared to summer (Table 1). Days of scouring were similar based on season, although duration tended to be longer in winter. The decrease in severity and incidence may be related to differences in colostrum quality from winter to summer.

Table 1. Mean scour incidence, severity and days of Holstein calves (N=77) housed in individual calf hutches from August, 1995 through July, 1996 in South Dakota.

	Season	
	Winter	Summer
Scour Incidence	0.67[a] (0.124)	1.19[b] (0.138)
Score	1.83[a] (0.131)	2.42[b] (0.145)
Days	12.42 (1.79)	9.09 (1.61)

[a,b]Within incidence, score or days, least squares means (SE) within a row with different superscripts differ (P<0.01).
[c]Score was based on a four-point scale with 1=normal feces to 4=watery feces.

Critical Temperature for Calves

Neonatal animals are especially susceptible to disease. Not only do they naturally have lower immunity than adult animals, but they also have lower critical body temperatures, making them more susceptible to environmental stressors. Lower critical temperature (Tlc) is defined as "that environmental temperature at which heat production first begins to rise (in the animal) as environmental temperature falls" (Blaxter, 1989). The lower critical temperature for calves varies based on the age of the calf (Davis and Drackley, 1998), ranging from approximately 56?F at 1 d of age to 43.5?F at 30 d of age. Alterations in the types of immune cells circulating in the blood of young calves occurs between approximately 40 and 50?F (Sorenson et al., 1997), indicating that the immune system of calves is affected when environmental temperature falls below the lower critical temperature. There are indications that the lower critical temperature of calves can be influenced by energy intake (Webster et al., 1978). Calves that are fed in a manner similar to veal calves, with large intakes of energy, may have critical temperatures as low as 7? to 16?F. If feeding diets with increased energy density decreases the temperature at which calves begin to use body reserves to generate heat, it may also lower the temperature at which alterations in the types of immune cells in blood occur. One suggested management strategy to maintain growth of young calves when environmental temperatures fall below the lower critical temperature (46?- 50?F) is to increase the energy density of the diet or add another feeding. This may also help the immune system resist disease organisms.

Immune cell phenotypes

Recent research (Franklin et al., 1998), revealed that proportions of several types of immune cells in calves varied during the year-long study. Results indicated that immune cell phenotype is affected by season (Figure 1) and extremes in environmental temperature (Figure 2). As environmental temperature increased, the proportion of monocytes decreased and CD2 T-cells increased. Monocytes are involved in an immediate response to an invasion by pathogens and CD2 T-cells are involved in long-term responses to a challenge that prepare an animal to mount a more effective immune response with later exposure to the same disease organism. Changes in the proportion of another type of T-cell, called gamma-delta T-cells, also were observed (with the percentage of gamma-delta T-cells greater during cold temperatures than during warm temperatures), but the changes were not as dramatic as those observed for T-cells and monocytes. Gamma-delta T-cells are found in higher percentages in calves than adult cattle, and may be involved in protection of the GI tract until other branches of the immune system mature.

These observations stimulated several questions. First, by determining the proportions of types of immune cells in a population, rather than absolute numbers, if one population increases, the other populations must decrease. For this study, there was a dramatic shift in both CD2+ T-cells and monocytes, indicating a real effect of temperature on the immune system. Second, although changes in the proportion of CD2+ T-cells as a result of environmental temperature were clearly demonstrated by this study, it was unknown which subtype of CD2+ T-cells (helper T-cells or killer T-cells) were affected. Third, it was not known how these changes in the proportions of circulating immune cells might affect immune responsiveness to particular diseases.

To address questions 1 and 2 from the previous data, 12 weaned Holstein heifer calves were followed over 6 weeks during natural (uncontrolled) temperature changes. During this test period, management of the heifers followed standard operating procedures for the University of Kentucky Dairy herd. Calves (3-5 months of age) were grouped together in free housing. Blood samples were obtained on four different sampling days, October 23, November 9, November 21 and December 5 corresponding to high (>60º F), moderate (50º F), low (<40º F), and a return to moderate (50º F) temperatures, respectively. Figure 3 illustrates total CD2, helper, and killer T-cells in response to temperature changes. Total T cells, and both helper and killer T-cells decreased in number with decreasing temperature. Further, there was a rebound effect of T cell subgroups during the moderate test day in December. There was a slight trend for monocytes to increase in absolute number during cold temperatures, as well as a notable increase in IL-2 receptor expression (data not shown). IL-2 is a receptor associated with immune cell activation and may indicate an increase in functionality of cells in colder temperatures. These data indicate an immunological shift that fluctuates as a result of changes in ambient temperatures. Photoperiod is not considered a factor in these data, because the cell phenotypes tended to fluctuate with temperature change, regardless of hours of daylight present. The December 5th moderate temperature date was close to the shortest day of the year in Kentucky, and still the leukocyte shift was increased to values obtained in November.

These data are important to calf immunity such that both major T-cell subtypes decrease due to temperature and season. Further the November 21 test day had only 36 hours of decreased temperature indicating an acute response of the calf immune system to a temperature fluctuation. Although season has been implicated in previous research as a variable in influencing immunity of other livestock, these data indicate that acute temperature changes may be enough to cause significant changes in immune status. Further research is planned to determine if the ability of calves to respond to disease challenge is compromised as a result of fluctuations in environmental temperature.

Summary

Season affects immune status of dairy calves and the presence of Ig in colostrum. Energetic demands for heat production in calves are increased in winter seasons, whereas in summer seasons heat dissipation and disease exposure are greater challenges. Dramatic alterations in immune cell phenotype occur in young calves less than 6 weeks of age and in weaned, pre-pubertal calves as a result of extremes in environmental temperature. Although shifts in the types of immune cells present in blood occur as a result of alterations in temperature, the

effects of these shifts on the ability of calves to resist disease challenge are still unknown. Based on these data, season may affect choice of timing of vaccination for calves if the immune response is altered.

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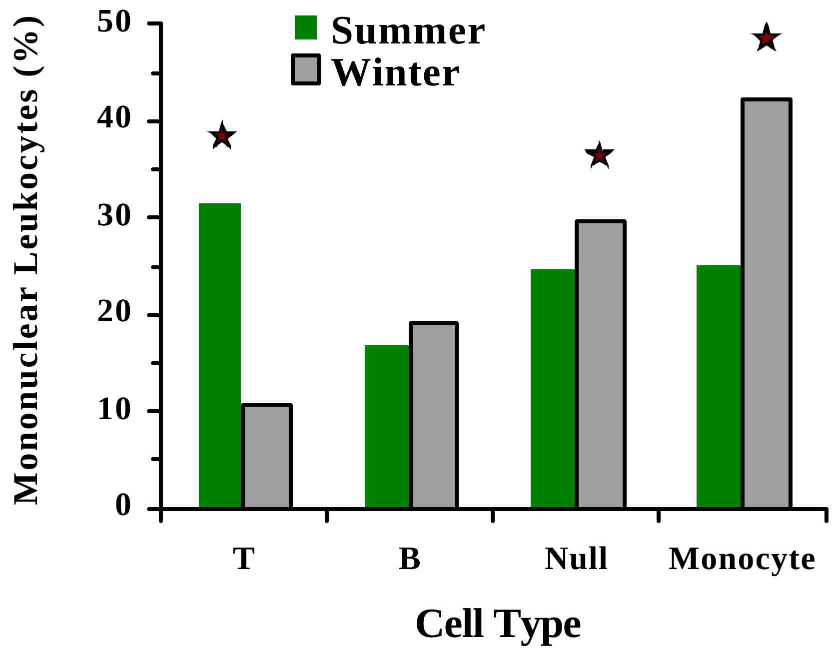

Figure 1. Effects of season on proportions of peripheral blood leukocytes from calves housed in individual calf hutches from August, 1995 through July, 1996 in South Dakota. * Denotes significant differences at P<0.05.

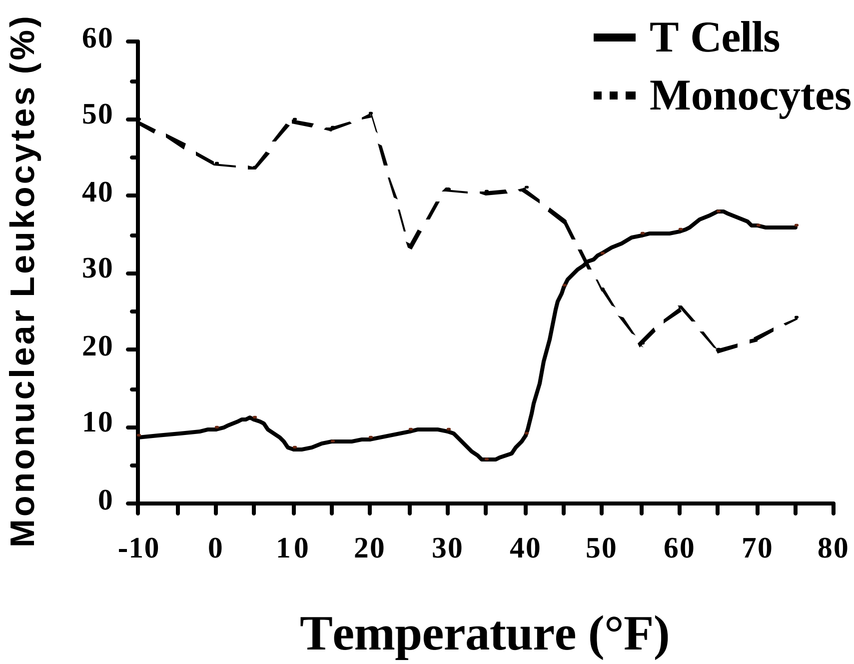

Figure 2. Effects of temperature on proportions of T-cells and monocytes from calves housed in individual calf hutches from August, 1995 through July, 1996 in South Dakota.

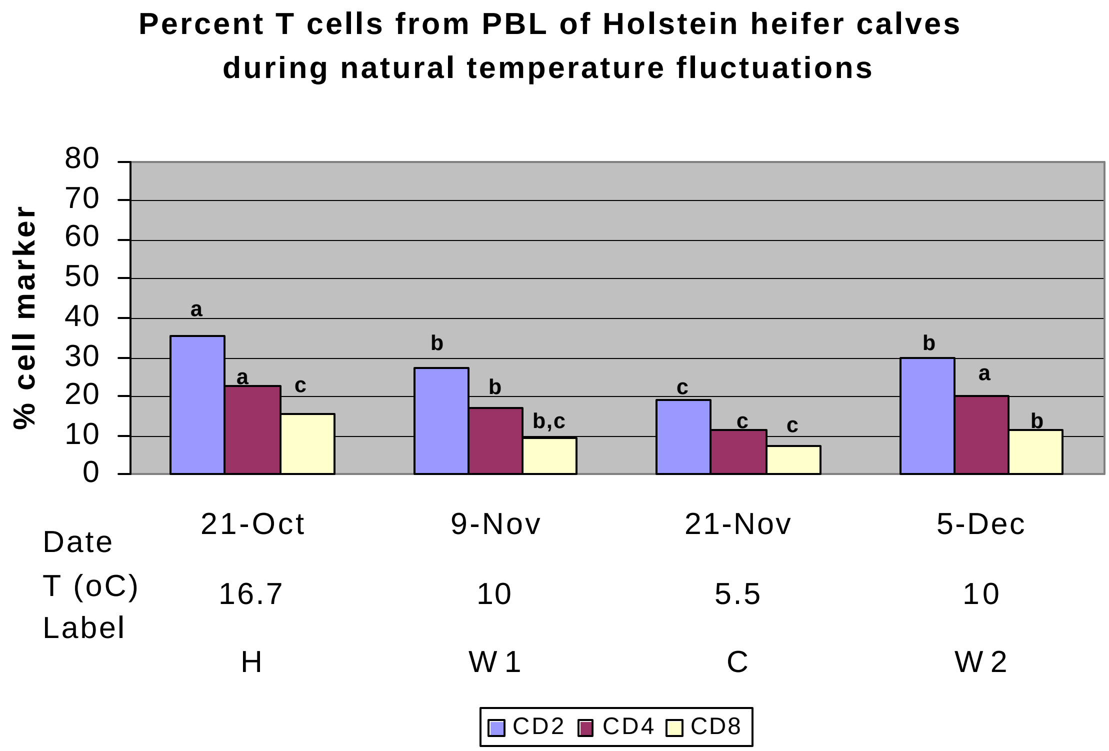

Figure 3. Proportions of T cells from weaned, pre-pubertal Holstein heifer calves exposed to natural temperature fluctuations.