Dairy Split Session II

Managing Environmental Stress

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Health of Newborn Holstein Calves in Severe Cold

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Morbidity and mortality among calves is a major concern of livestock producers, veterinarians, and animal health researchers world-wide. Notwithstanding use of the newest antibiotics and vaccines, death among neonatal calves has continued virtually unabated.[1] In an effort to combat these losses many producers raise calves individually in calf hutches[2] which serve to isolate calves from each other and from older cattle which act as carriers of disease organisms.[1]

It is not uncommon for many areas of the northern U.S. and Canada to experience prolonged periods during winter when effective ambient temperatures are well below 0 C. Calves raised in hutches during such weather may be exposed to temperatures and environmental conditions requiring a level of heat production which exceeds the energy content of feed. Efforts to maintain body temperature within normal limits under such conditions will result in energy malnutrition, accompanied by weight loss, ill health, or hypothermia. It is possible that chronic exposure of calves to severely cold temperatures might account for some morbidity and mortality among calves during winter, particularly for undersized or diseased calves or when management practices are inadequate.

Many studies of the effects of cold stress on calves have been conducted. Effects of acute exposure of calves to cold water which quickly produced hypothermia have been extensively documented[3 4 5 6 7 8 9] Hypothermic calves have signs of physical weakness, depression, loss of vigor, difficulty nursing and are reluctant to stand or walk.[3] Alterations occur in a number of important serum electrolyte and hemic values including white blood cell count, red blood cell count, hemoglobin concentration, packed cell volume, and the serum concentrations of glucose, sodium, potassium, chloride, and calcium.[8 9]

Studies of heat exchange and insulation of young calves exposed to cold environments have also been done.[10 11 12] However, the latter experiments involved either confinement of calves to a calorimeter for relatively short periods or exposure of calves to constant temperature which were above freezing. Studies of insulation have been conducted using calves which were acclimatized to cold temperatures.[13] Newborn calves, by virtue of their being enclosed in a warm uterus for the previous 9 months, apparently do not have opportunity for such acclimatization. In addition, like most juvenile animals, newborn calves might be expected to differ substantially from adult animals in their sensitivity to cold.[14]

Information gained from previous studies is of limited use in evaluating cold tolerance and thermal regulation of young calves housed in hutches during severely cold winter weather. Despite the economic importance of raising healthy dairy calves, little information exists concerning the effects of chronic exposure of calves to very low environmental temperatures which, under field conditions, seem to have the potential for producing hypothermia.

Methods

To investigate the effects of chronic exposure of young calves to subfreezing temperatures, newborn, male, Holstein calves were housed in calf hutches in environmental chambers. Air temperature inside one chamber was maintained at 17 C while that in a second chamber was made to cycle on a daily basis from a low temperature at 0600 h, rising 1 degree C per hour to a high temperature at 1800 h, then falling again in

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like manner to the low temperature. Temperature extremes in different experiments were -20 to -8 C or -30 to -18 C. Calves in one group at the coldest temperature were outfitted with an insulated coat.

Calves were housed in hutches within chambers from day of birth until 3 weeks of age. Blood was drawn 3 times per week for determination of hemic and serum chemistry components. Physical examination was conducted daily. Metabolic rate was determined by indirect calorimetry in standing and recumbent positions using a tightly fitting face mask and collecting expired air in a Douglas bag. Insulation (tissue and external) was calculated based on skin temperature measurements using 30-gauge copper-constantan thermocouples applied bilaterally to the skin in 12 locations using a cyanoacrylate glue. Additional thermocouples were used to measure both rectal and ambient air temperature within hutches.

Results

Clinical assessment:

All calves maintained good vigor and aggressiveness. Values for red blood cell count, white blood cell count, packed cell volume, hemoglobin concentration, and serum concentrations of glucose, sodium, potassium, chloride, and calcium indicated few important effects due to 3 weeks of exposure of calves to temperatures varying between -20 and -8 C or between -30 and -18 C. Small but statistically significant changes in chloride concentration were seen in both cold treatment groups; the importance of these changes was not clear. Compared to warm-housed controls, mean white blood cell count was lower for calves at -20 to -8 C, whereas white blood cell count of calves housed at -30 to -18 C was higher. Calves wearing an insulated coat at -30 to -18 C had a mean white blood cell count that was lower in comparison to calves without an insulated coat. Despite these differences, however, white blood cell count of all calves was within a clinically normal range.

Rectal temperature was affected by cold treatment only in calves housed at -20 to -8 C. This difference in rectal temperature was statistically significant but of no clinical importance. In all cold-housed calves respiratory rates tended to be lower and heart rate was elevated. No changes in rectal temperature, heart rate or respiratory rate were associated with wearing the insulated coat. Average daily gain of calves in all treatment groups were not significantly different from controls.

Necropsy:

At necropsy, cold-housed calves had subcutaneous hemorrhage and edema of the hindlimbs. Evidence of an inflammatory process was not detected in any case. These lesions have been observed clinically in association with "weak calf syndrome"[15] and, in the laboratory, similar lesions have been observed in hypothermic calves.[3 5] Although the lesions did not seem painful and were not evident in life, hemorrhages were quite apparent at necropy. The insulated coat did not prevent the occurrence of the lesions.

Metabolic rate:

Metabolic rate of recumbent calves housed at -20 to -8 C was not significantly different from recumbent warm-housed calves. Although metabolic rate of recumbent calves housed at -30 to -18 C was higher than recumbent calves at 17 C, the increase was minimal in that the metabolic cost of standing in a thermoneutral environment was 4.1% greater than the cost of recumbency in a chamber at -30 to -18 C. Metabolic rate of calves wearing an insulated coat at -30 to -18 C was lower on the day of birth when compared to calves without a coat at the same temperature. Metabolic rate of coated calves increased during the first 3 weeks of life to a level comparable to that of calves without insulated coats.

Insulation:

Tissue and external insulation values of all cold-housed calves were significantly elevated over controls. Tissue insulation increased in cold-housed groups during the first two weeks of life while external insulation did not change significantly during the same period. The insulated coat significantly improved external insulation of calves housed at -30 to -18 C.

Discussion

It was concluded that the microenvironment, consisting of the hutch and straw bedding, played a key role in the energy balance of calves since the ambient temperature to which calves were exposed was below the lower critical temperature for newborn calves previously reported in the literature.[10] (Lower critical temperature is defined as that temperature below which an animal must raise its metabolic rate in order to maintain a stable core body temperature.) That the metabolic rate of recumbent calves housed at -20 to -8 C was not elevated over that of recumbent warm-housed calves supports the conclusion that the lower critical temperature of cold-housed calves was reduced when calves were recumbent. Although it was expected that cold-housed calves would have elevated metabolic rates while standing, moving, or shivering, the surprising effectiveness of the hutch and straw bedding in reducing heat loss while calves were in the recumbent position was not anticipated. By a modification of physiologic and behavioral thermoregulatory mechanisms, it is possible that a healthy calf housed in a dry, well bedded hutch during severely cold weather would expend no more energy on a daily basis than a calf housed at a thermoneutral temperature.

This conclusion was supported by the observation that average daily gains of cold-housed calves were not significantly lower than those of warm-housed controls. The energetic demand of a fluctuating thermal environment between -20 and -8 C or between -30 and -18 C was not sufficient to produce a significant reduction in average daily gain. This is a good indication of the cold tolerance of newborn calves housed in hutches, considering that these temperatures are well below the lower critical temperature for young calves.

Values for tissue insulation were 5-8 times less than those obtained for external insulation. This was in contrast to studies involving older calves housed outdoors in winter in which tissue insulation was more than one half, and sometimes greater than, external insulation.[13] Although the contribution of tissue insulation was not insignificant, newborn calves depended on external insulation to a greater degree for protection from the cold environment. This has important implications for health and well-being of calves.

It is well known that wind and moisture can adversely affect the insulating value of hair coats. In order to maintain body temperature under conditions which compromise the natural protection afforded by the hair coat, the only alternative available to calves is to increase heat production to offset increased heat loss. Energy to support an increase in heat production must come from body stores or feed. Rations which are adequate under good management conditions may prove to be hypocaloric when heat loss to the environment is excessive. The latter situation would occur when calves are housed in an environment (*i.e.,* wet bedding, precipitation, draft) which destroys the insulation of the hair coat. All of the findings of the present study (including hematology, serum chemistry, daily clinical examinations and behavioral assessments) indicated that cold temperature in and of itself was not detrimental to health and well-being of calves. Poor management may play a more important role than is commonly recognized in explaining some starvation and death among calves in cold environments.

Average daily gain of calves with insulated coats was not statistically different from that of calves without coats. Apparently coated calves wasted excess energy rather than retain energy in body stores. Based on considerations of energetics, general use of an insulated coat for protection of healthy, well managed calves is questionable. The insulated coat could provide a margin of safety for small or sick animals which must be housed in cold environments. It is clear, however, that healthy, newborn, adequately fed calves housed in dry, unheated hutches in a very cold environment do not require external assistance in order to maintain rectal temperature or good health.

In summary, it was found that 3 weeks of exposure to a fluctuating environmental temperature either between -20 and -8 C or between -30 and -18 C was not detrimental to the growth and health of young dairy calves. As a consequence of the design of the experiment, infectious disease was not a confounding factor and effects of cold exposure alone could be studied. It was also concluded that the interaction between the calf and its microenvironment, the hutch and bedding, was a prime factor in the cold tolerance and, thus, well-being of calves housed in the cold environments. It seems that only when elements in addition to cold temperature are introduced, such as infectious disease, wet bedding, inadequate shelter or exposure to wind or drafts, would calves actually be put at risk.

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Questions & Answers:

Question: In our part of the country we encounter respiratory problems in calves experiencing ambient temperatures between day and night of more than 20° F. Is this something that you could do some work on?

Answer: This is a very interesting problem. Most experiments have been done on constant temperature conditions but the circadian rhythm and temperature we use is unique. Our method makes a profound difference to the calves. A broader extreme of temperatures would be worth looking at.

Question: What milk replacer do you use?

Answer: We use Land-O-Lakes all milk replacer with 20% fat, fed at rate of 150% of the package recommendation, so they received half as much again of solids. No grain was fed because we wanted strict control on their intake.

Question: Do you see any variation in starting calf size?

Answer: All our calves came from the same farm so they were genetically very similar in size, most about 105 pounds, but we had a set of twins in the 60s but they performed just as well as the others.

Question: Did the farm they came from have warm housing?

Answer: The farm has a 0.5% death rate in calves. They are raised in hutches. The dairy cows are cold housed. This raises an interesting problem in that cold housed cows, during winter might deliver calves that are better prepared for the winter. We conducted our experiment year round so that summer born calves were put in winter like conditions — born to cows exposed to warm temperatures but the calves were put into the winter conditions. It is a possibility that the exposure of the cow to cold weather can affect the calf's ability to cope with cold conditions.