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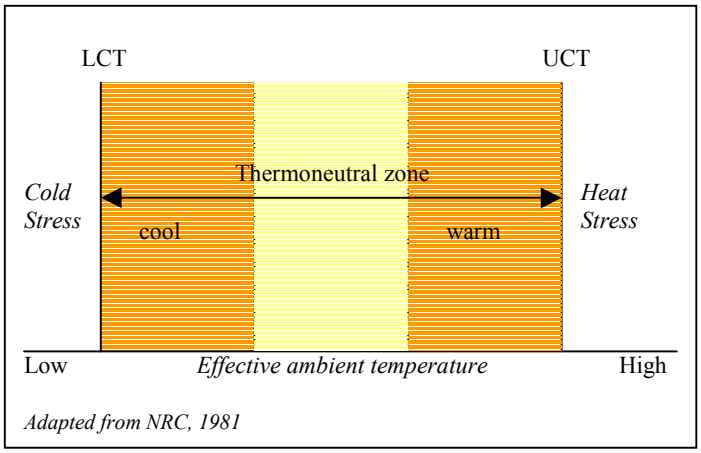
Calf Note #59 – Environmental Effects on Calf Feeding – Basic Concepts

Introduction

Feeding milk or milk replacers to young calves often means feeding them for limited amounts of energy and protein to stimulate rumen development and allow early weaning. When the weather gets too cold (or too hot), animals must use energy to maintain their core body temperature. This energy detracts from growth and may have a negative effect on efficiency and even health. This Calf Note is designed to provide the background to help you understand the concepts of energy metabolism and the need for additional energy in cold weather.

Basic Concepts

All homeothermic animals maintain a constant body temperature. That is, they maintain a their internal temperature within strict limits regardless of the external environment. These animals will "defend" or work to maintain their body temperature when the outside environment moves outside this range. This range of temperature is called the *thermoneutral zone* (**TNZ**), which is defined as the range of temperature within which the animal uses no additional energy to maintain its body temperature. This range is bounded by the *lower critical temperature* (**LCT**) and *upper critical temperature* (**UCT**) as shown in the figure:



Adapted from NRC, 1981

The figure includes the term "*effective ambient temperature (EAT)*". This is the actual temperature felt by the animal, which may be very different from the air temperature. It is important to consider the micro-climate immediately surrounding the animal to determine the EAT. For example, the EAT of a calf housed in a clean, dry hutch bedded with straw may be 8 to 10ºC warmer than the air temperature. Conversely, the EAT of a heifer exposed to wind and rain may be considerably lower than the ambient temperature.

Movement of heat from the body can be accomplished by radiation, evaporation, convection or conduction.

Radiation is the transfer of heat from the surface of one object to another without contact between the two surfaces. Often, heat will "radiate" from one surface (skin) to another, cooler, surface (such as the cold wall of the pen or hutch) although the calf is not actually touching the pen wall. Under

non-stressful environmental conditions, radiation can account for a significant portion of heat loss from the animal's body.

The amount of heat lost by radiation depends on the amount of heat at the surface of the skin. In very hot temperatures, blood vessels dilate to increase blood flow (and heat) to the surface, where it can radiate from the body. In very cold temperatures, vasoconstriction reduces the amount of heat reaching the surface of the body, thereby reducing radiant heat loss.

Convection is the transfer of heat away from a surface by movement of heated air or fluid. Under most circumstances, convection accounts for little heat loss away from the surface of an animal's body, but can increase under some circumstances.

Conduction refers to the transfer of heat from one surface to another while the two surfaces are in contact with each other. Conduction usually accounts for a small amount of heat loss, except when an animal lies on a very cold floor.

When water is converted from liquid to gas (*evaporation*), there is a loss of energy from the body. The evaporation of sweat from the body constitutes a powerful mechanism for eliminating heat. At high environmental temperatures, evaporation becomes the primary mode of heat dissipation. However, the rate of evaporation depends on the humidity in the air. Humid environments depress the rate of evaporation and make hot temperatures seem even hotter. Evaporation occurs not only through evaporation of water on the body surface (sweat) but also through breath. In very hot climates, animals will pant to increase evaporative loss of heat

An animal's tolerance to heat and cold is in part determined by its' surface area. Calves have a much larger surface area per unit of body weight than mature cows. Therefore, heat loss by convection and conduction are much more important to calves than cows. The surface area of an animal is a function of the animal's height and width. However, typically for cows, the surface area is not calculated. Instead, researchers have determined that the *metabolic body weight* is closely related to basal metabolism (and heat loss). Metabolic body weight (MBW) is usually calculated as a function of body weight (BW):

$$MBW\ (kg) = BW^{0.75}$$

The table shows the calculation of MBW based on live body weight is show in the table.

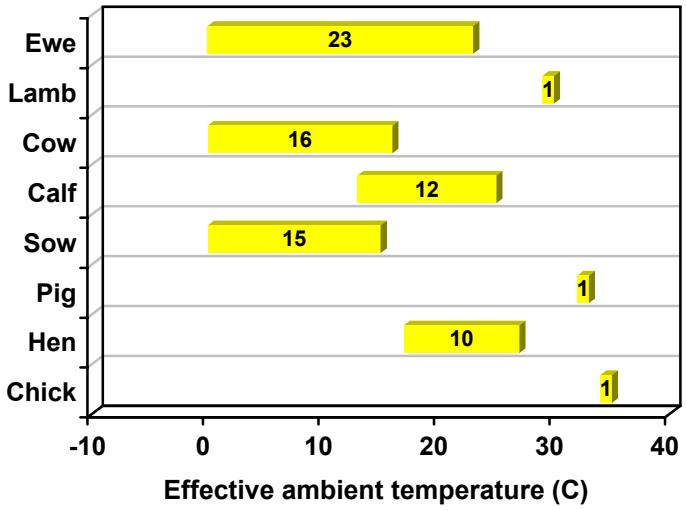
BW (kg)	MBW (kg)	BW (kg)	MBW (kg)
30	12.8	110	34.0
35	14.4	120	36.3
40	15.9	130	38.5
45	17.4	140	40.7
50	18.8	150	42.9
55	20.2	160	45.0
60	21.6	170	47.1
65	22.9	180	49.1
70	24.2	190	51.2
75	25.5	200	53.2
80	26.7	210	55.2
85	28.0	220	57.1
90	29.2	230	59.1
95	30.4	240	61.0
100	31.6	250	62.9

Some factors that affect an animal's TNZ include:

- *Wind.* The movement of air around an animal will profoundly affect its ability to maintain body temperature. Air movement increases evaporation and heat convection. In very cold temperatures, wind chill is used to calculate the effective temperature. In hot temperatures, wind can increase evaporation, thereby cooling the animal. Calves and heifers less than one year

of age can benefit from some type of shelter from wind in most climates. Newborn calves are especially susceptible to effects of temperature (particularly cold temperature), so a shelter for newborns is essential.

- *Moisture.* Typically measured as humidity, the amount of moisture in the air can affect an animal's ability to maintain thermoneutrality, particularly in hot, humid climates. In this case, evaporation of water from the skin is important to cooling an animal. High humidity can reduce the rate of evaporative cooling, thereby increasing heat stress.
- *Precipitation.* Rain and snow wet the hair coat, reducing or eliminating its insulation value. In very hot temperatures, heat loss can be a welcome relief; in cold temperatures, rain or snow can cause dramatic increases in heat loss.
- *Hair coat.* An animal's hair coat provides insulation from the outside environment and can dramatically affect its ability to maintain thermoneutrality. This is particularly true in cold climates when insulation from cold temperatures is important. The hair coat holds a layer of "dead air" that insulates the animal. When the air space is interrupted (e.g., manure, water, urine, mud, etc.), the insulative value of the hair coat is markedly reduced. This can impair the calf's ability to thermoregulate. If an animal has a hair coat caked with manure and mud in cold temperatures, the animal's basal metabolism must increase to compensate for the added heat loss. Wisconsin researchers have proposed increased energy requirements for heifers under various environmental conditions with different amounts of body mud (Hoffman, 1996).
- *Shelter.* Shelter serves to reduce the effects of precipitation, wind and other elements on an animal's ability to maintain heat balance. For calves, shelter is important, because their insulation (as hair coat) is relatively low and surface area is high. Therefore, shelter is very important to calves – especially preruminant calves. Shelter should provide protection from the elements; however, heating calf and heifer housing is unnecessary under most conditions.
- *Radiation.* Radiation received by an animal is somewhat offset by the release of radiation by the animal (as "long-wave" radiation). However, in sunlight, there is usually a net gain of heat by an animal. It has been estimated that the EAT may be increased by as much as 3-5°C in animals in sunlight. During periods of cold stress, this additional heat may be quite beneficial; on the other hand, in the summer, radiation may be a problem.



- *Bedding.* Bedding reduces the conduction of heat from the animal into the floor or ground. In addition, an animal may alter its posture to increase or decrease conduction and maintain thermoneutrality. The type of bedding (ability to absorb moisture) affects the hair coat of the animal
- *Rumination.* Calves that consume dry feed will begin to produce significant amounts of heat by rumen fermentation. Rumen bacteria ferment carbohydrate in feed to volatile fatty acids and microbial protein. During this process, heat is liberated as a normal by-product of fermentation. This heat can help a calf deal with cold, effectively lowering its LCT by several degrees.

Effects of EAT on Digestibility

Researchers have shown in many species (including beef and dairy calves) that temperatures outside the thermoneutral zone can affect digestibility of the diet. Total intake of DM can affect digestibility in animals; therefore, heat and cold stress can affect intake, which may affect digestibility. Typically, cold stress causes increases in DM intake as the animal attempts to consume sufficient energy for maintenance. Increased intake can reduce digestibility as rates of passage increase. However, some research suggests that changes in ruminal volume and rate of passage may also occur during heat stress. During cold stress, increased volume and rates of passage have been reported. This has important implications for young (preweaned) calves, as they are often limit-fed and the amount of ME intake does not markedly exceed maintenance.

Conclusions

It is important to remember that the information in this Calf Note should be used as a guide only. Susceptibility to heat or cold stress depends on many factors, including adaptation, housing, management, and many other factors. Determining nutrient requirements for animals exposed to different climates and EAT is a significant challenge that requires consideration of many factors affecting the animal's ability to maintain a normal environment.

Heat and cold outside the thermoneutral zone will force an animal to utilize compensatory mechanisms to maintain its body temperature within normal limits. Management, housing, diet, and climate all affect the energy requirements of the animal. Other Calf Notes will address the practical changes in nutrient requirements needed to maintain optimal growth.

References

1. NRC, 1981. The effect of environment on nutrient requirements of domestic animals. National Academy Press, Washington, DC.

2. Hoffman, P.C. 1996. Replacement heifer nutrition: breeding to precalving. Page 262 in Calves, heifers, and dairy profitability. Proceedings from the Calf, Heifers and Dairy Profitability National Conference, Harrisburg, PA. NRAES-74, Ithaca, NY.

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