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Calf Note #249 – Musings on cold weather

Introduction

Calves, like most animals, produce heat to stay warm in environments outside of their thermoneutral zone. The idea of a "zone" of temperatures within which a calf is comfortable and uses no additional energy to maintain its body temperature is well known. Here is a graphic of the concept from a 1981 NRC publication:

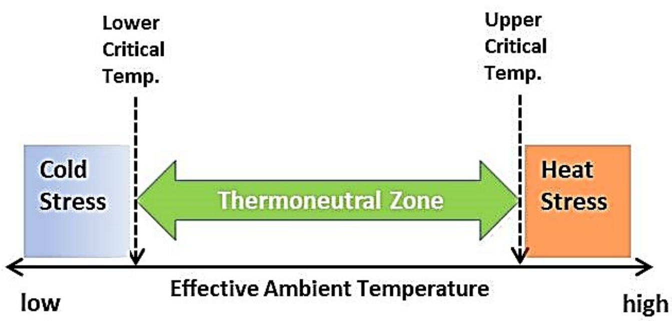

Figure 1. Schematic of relationship of temperatures to thermal zones. From: 1981 NRC.

Of course, the actual thermoneutral zone (**TNZ**) depends on the class of animal, diet, maturity, and other factors. When the effective ambient temperature (**EAT;** the temperature that the calf actually experiences) rises above the upper critical temperature (**UCT**) or falls below the lower critical temperature (**LCT**), the calf will use energy to try to maintain its body temperature. When we know the LCT or UCT, we can provide the additional energy in the diet that the calf requires so the animal can continue to grow normally. The manner in which we calculate the LCT is the topic of this Calf Notes.

Two LCT values

The 2021 NASEM Nutrient Requirements for Dairy Cattle uses two different LCT thresholds, based on the age of the calf. The LCT for calves younger than 21 days of age is 15°C and for calves older than 21 days, the LCT is 5°C. The UCT, on the other hand, is fixed for all calves and is 25°C. Above 25°C, calves will begin using energy to try to dissipate heat. The TNZ and UCT and LCT are in the Figure below, which shows the total net energy requirement for maintenance at various EAT. The NEm requirement for a 50-kg calf is about 2 Mcal/d and begins to increase in calves less than 21 d of age (yellow line) below 15° whereas older calves will begin using more energy below 5°C. Using values in Figure 2, we can calculate the amount of extra energy needed and ensure that the calf is offered the additional energy to maintain adequate growth in periods of cold.

The 2021 NASEM derives its recommendations from the 2001 NRC Nutrient Requirements of Dairy Cattle, which also set a fixed LCT for calves less than and greater than 21 days.

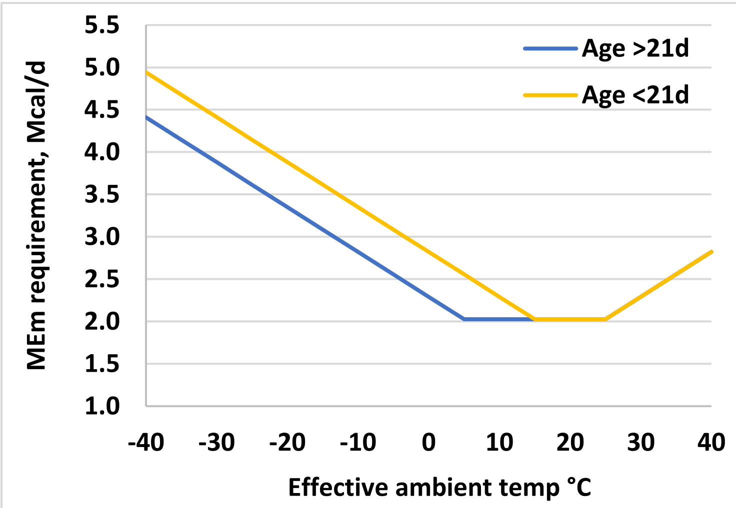

Figure 2 Change metabolizable energy required for maintenance (MEm) at various temperatures in calves <21 and >21 days of age.

I was a bit curious about the manner in which the LCT was determined, so I looked at both publications to find a clue. However, neither publication explains the origins of the calculation of 5° and 15°. The 2001 NRC states the following

"The thermoneutral zone in very young calves ranges from 15– 25° C. Thus, when the environmental temperature drops below 15° C, which is referred to as the lower critical temperature, the calf must expend energy to maintain its body temperature. In practical terms, the maintenance energy requirement is increased. For older calves and calves at greater feed intakes, the lower critical temperature may be as low as -5 to -10° C (Webster et al., 1978)."

The same information is repeated in the 2021 publication. However, when we look at the 2001 NRC in Chapter 11 (Growth of Heifers), a set of calculations is available to allow us to calculate the LCT. I include these calculations in Appendix A for your reference. Interestingly, calculating LCT or UCT was not retained in the 2021 NASEM for heifers. The approach to calculating LCT uses estimates of heat production and insulation of the animal's body and hair coat characteristics. Many of the estimates here are based on data developed in the 1940's and 1950's.

Obviously, there's a big difference between simply assuming two constants (15°, 5°) versus a whole series of calculations. However, if we look into the calculations, there are a couple of important factors that we should consider in light of today's calf feeding and management. Let's consider one of those in more detail.

Intake and heat production

The heat produced by an animal is highly related to the amount of energy it consumes and the amount of that energy that it can retain in the body. Animals are not 100% efficient and will lose energy as heat during digestion. The amount increases with increasing intake.

Table 1 is from a manuscript published in 1962 (Gonzalez-Jimenez and Blaxter, 1962). In this study, calves were fed either 4 or 6 liters of whole milk per day and were housed at 23°C. We see the amounts of energy consumed (intake) and lost in feces, urine, heat, and the amount of energy retained in the body.

Calves fed 4 liters of milk lost 1,990 kilocalories per day, which represented 68% of their total energy intake. That's quite significant, but that energy might be available to be used to maintain body temperature if the calf is housed in the cold. Calves fed 6 liters of milk lost 2,399 kilocalories of heat per day. That is an increase of +24% compared to calves fed 4 liters. These calves were more efficient in using ingested energy (the lost only 55% of their ingested energy as heat) but still lost a greater amount of total heat to the environment.

Table 1. Energy utilization in calves fed varying amounts of whole milk. From: Gonzalez-Jimenez and Blaxter, 1962.

	Energy, kcal/day				
Milk	**Intake**	**Feces**	**Urine**	**Heat**	**Retained**
4 L	2,937	33	75	1,990	840
6 L	4,355	82	80	2,399	1,894

What are the implications to all of this? Well, if we feed a two-week old calf 4 liters of whole milk as in the study by Gonzalez-Jimenez and Blaxter (1962) and assume the calf is 50 kg, housed inside with a clean dry coat and no wind, and using the energy balance data in Table 1, we calculate the LCT = 18°C. On the other hand, using the data in Table 1 for calves fed 6 liters of milk, the LCT = 12°C. With greater amounts of energy consumed – and more energy lost as heat – the LCT for a calf declines.

Today, we feed calves more milk and milk replacer than in the past. The NRC and NASEM calculations seem to be based on milk intakes somewhere in the range of 4 to 6 liters per day. When calves are fed 8 to 10 liters of liquid per day, their LCT will be much lower. Using existing equations within the NASEM model, it's possible to calculate a variable LCT for calves fed different amounts of energy under different conditions.

Table 2. Calculated LCT of calves (°C) in calves at various ages and intakes of whole milk.

	Day of age			
L whole milk	7	14	21	28
4	17.0	16.0	8.3	5.0
6	10.8	9.8	1.6	-1.7
8	4.6	3.5	-5.0	-8.3
10	-1.6	-2.8	-11.5	-14.8

Calves assumed to eat 0, 0.1, 0.4, and 0.6 kg of calf starter per day at 7, 14, 21, and 28 d of age, respectively. Calves assumed BW of 45, 50, 55, and 60 kg at 7, 14, 21, and 28 d of age, respectively.

Table 2 shows the LCT of calves at various ages and amounts of whole milk consumed. Note that the LCT for calves from 7 and 14 days of age and 4 to 6 liters of whole milk intake is quite close to the 15° described by NASEM. Similarly, LCT for calves at 21 and 28 days of age isn't far from 5°C. However, as the amount of milk consumed by calves increases, the LCT declines so that a 7-day old calf drinking 10 liters of milk will have an LCT below zero. The amount of heat produced from 10 liters of milk will be much greater compared to 4 liters.

The lower critical temperatures for older calves and particularly when they consume greater amounts of feed are well below zero. While these values seem extreme, the 201 NASEM refers to a study by Webster et al. (1978) that reported LCT from -5 to -10 in older calves with greater dry feed intake. Thus, values in Table 2 appear to reflect the situation at high feed intake.

Summary

Calf LCT depends on the insulation value of the skin plus haircoat and amount of heat produced by animal. The LCT used by 2021 NASEM appear to be based on limited ME intake of approximately 4 to 6 liters of milk or milk replacer per day. Increased feeding levels will reduce the LCT. Incorporation of a variable calculation of LCT should improve predictions of energy requirements for calves to four months of age.

For a downloadable Excel file to quickly calculate LCT, visit Calf Notes website.

References

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Appendix A. Calculations used to calculate LCT.

[1]	SBW = shrunk body weight, kg;
[2]	SA (surface area, m²) = 0.09 × $SBW^{0.67}$;
[3]	RE = retained energy, Mcal/day;
[4]	MEI = ME intake, Mcal/day;
[5]	HP (heat production, Mcal/m²/day) = (MEI – RE) / SA;
[6]	Wind = wind speed, kph;
[7]	Hair = hair depth, cm;
[8]	Coat = adjustment for coat insulation value, 1 = clean/dry, 2 = limited mud, 3 = wet, 4 = covered with mud or snow;
[9]	EI (External insulation value, °C/Mcal/m²/day) = (7.36 – (0.296 × Wind) + (2.55 × Hair)) × Coat;
[10]	TI (Tissue insulation, °C/Mcal/m²/day) = 2.5 for newborns; 6.5 for 1 month old calf; 5.1875 + (0.3125 × BCS) for year-old heifers; and 5.25 + (0.75 BCS) for adult cattle;
[11]	NS (Insulation value, °C/Mcal/m²/day) = TI + EI;
[12]	LCT = 39 – (INS × HP × 0.85);

Source: CNCPS and NRC, 2001.

Written by Dr. Jim Quigley (4 March 2024)

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