What We Have Learned About Cross Ventilated Freestalls: A Producer Panel

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Introduction

Low profile cross ventilated (LPCV) freestall buildings are one option for dairy cattle housing. These facilities allow producers to have control over a cow's environment during all seasons of the year. As a result, an environment similar to the thermoneutral zone of a dairy cow is maintained in both the summer and winter, resulting in more stable core body temperatures. LPCV facilities allow for buildings to be placed closer to the parlor, thus reducing time cows are away from feed and water. Other advantages include a smaller overall site footprint than naturally ventilated facilities and less critical orientation since naturally ventilated facilities need to be orientated east-west to keep cows in the shade. Some of the other benefits to controlling the cow's environment include increased milk production, improved feed efficiency, increased income over feed cost, improved reproductive performance, ability to control lighting, reduced lameness, and reduced fly control costs.

Characteristics of LPCV Facilities

The "low profile" results from the roof slope being changed from a 3/12 or 4/12 pitch common with naturally ventilated buildings to a 0.5/12 pitch. Contractors are able to use conventional warehouse structures with the LPCV building and reduce the cost of the exterior shell of the building, but the interior components and space requirements per cow for resting, socializing, and feeding in an LPCV building are similar to a 4-row building.

Providing a Consistent Environment

Constructing a cross ventilated facility ensures the ability to provide a consistent environment year-round, resulting in improved cow performance. These buildings provide a better environment than other freestall housing buildings in the winter, spring and fall months, as well as the summer because of the use of an evaporative cooling system. The ability to lower air temperature through evaporative cooling is dependent upon ambient temperature and relative humidity. As relative humidity increases, the cooling potential decreases, as shown in Figure 1. Cooling potential is the maximum temperature drop possible, assuming the evaporative cooling system is 100% efficient. As the relative humidity increases, the ability to lower air temperature decreases, regardless of temperature. The cooling potential is greater as air temperature increases and relative humidity decreases. Figure 1 also shows that evaporative cooling systems perform better as the humidity decreases below 50 percent.

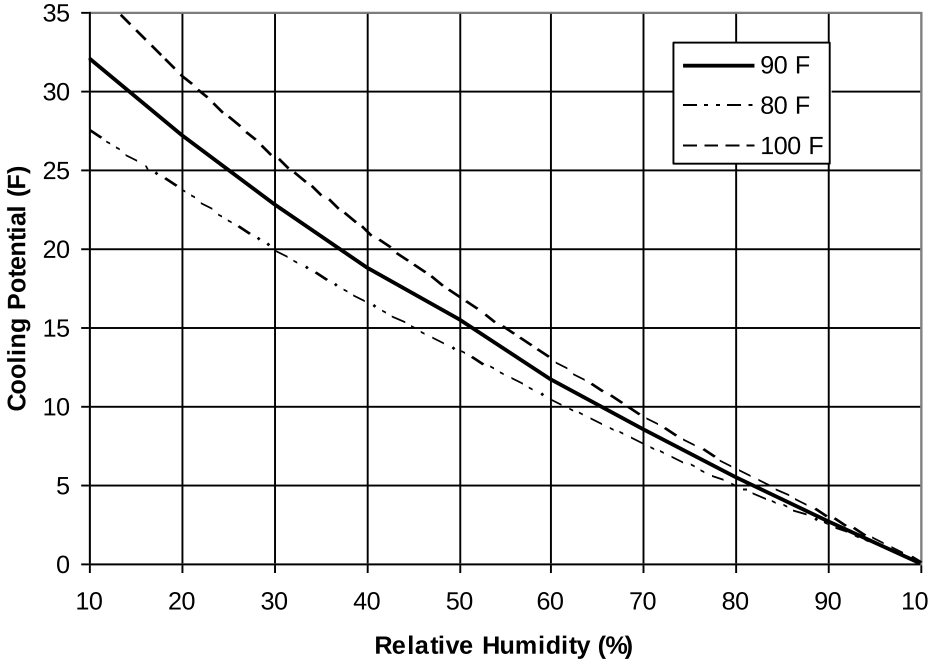

Figure 1: Impact of Relative Humidity and Temperature on Cooling Potential When Using an Evaporative Cooling System

Impact of LPVC Facilities and Core Body Temperature

One of the major benefits of LPCV facilities is the ability to stabilize a cow’s core body temperature. A heat stress audit was conducted on a North Dakota dairy to evaluate the impact of a changing environment on the core body temperature of cows. Vaginal temperatures were collected from 8 cows located in the LPCV facility and 8 cows located in a naturally ventilated freestall facility with soakers and fans. Data were recorded every 5 minutes for 72 hours using data loggers (HOBO® U12) attached to a blank CIDR® (Brouk 2005). Environmental temperature and humidity data were collected on individual dairies utilizing logging devices which collected information at 15 minute intervals. The environmental conditions and vaginal temperatures during the evaluation period are presented in Figures 2 and 3. Vaginal temperatures were acceptable in both groups, but the temperatures of cows housed in the LPCV facility were more consistent. Feedline soakers in naturally ventilated buildings are effective in cooling cows, but they require the cows to walk to the feedline to be soaked. On the other hand, cows in an LPCV facility already experience temperatures that are considerably lower than the ambient temperature. Reducing the fluctuations in core body has a dramatic impact on the production, reproduction and health of a dairy cow.

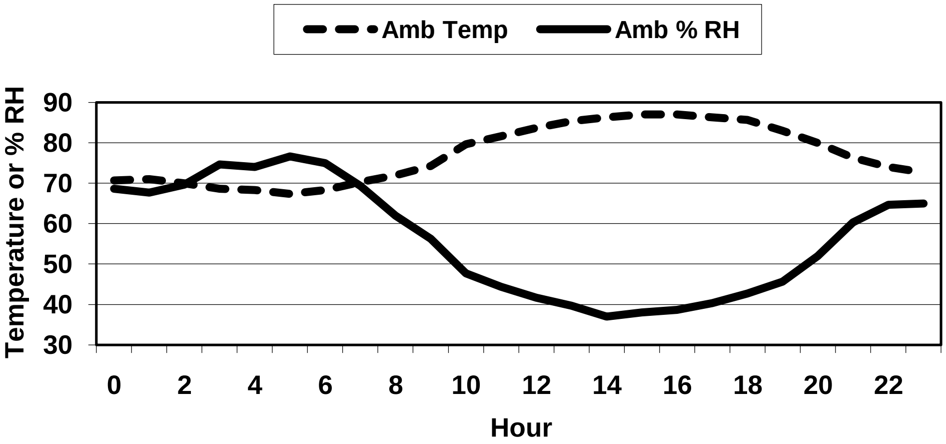

Figure 2: Ambient Temperature and % RH for Milnor, ND (July 6-9, 2006)

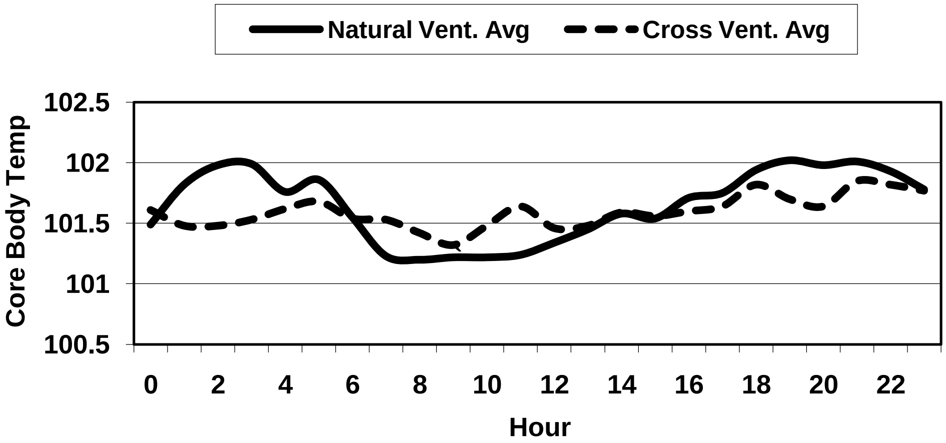

Figure 3. Core Body Temperature of Cows Housed in Naturally Ventilated (Fans & Soakers) and LPVC Freestalls (Evaporative Pads)

Environmental Impact on Nutrient Requirements and Efficiency

Dairy cows housed in an environment beyond their thermoneutral zone alter their behavior and physiology in order to adapt. These adaptations are necessary to maintain a stable core body temperature, but they affect nutrient utilization and profitability on dairy farms.

The upper critical temperature, or upper limit of the thermoneutral zone, for lactating dairy cattle is estimated to be approximately 70 - 80°F (NRC, 1981). When temperatures exceed that range, cows begin to combat heat stress by decreasing feed intake (Holter at el., 1997), sweating, and panting. These mechanisms increase the cows' energy costs, resulting in up to 35% more feed necessary for maintenance (NRC, 1981). When dry matter intake decreases during heat stress, milk production also decreases. A dairy cow in a 100°F environment decreases productivity by 50% or more relative to thermoneutral conditions (Collier, 1985).

Compared to research on the impact of heat stress, little attention has been paid to cold stress in lactating dairy cattle. The high metabolic rate of dairy cows makes them more susceptible to heat stress in U.S. climates; so as a result, the lower critical temperature of lactating dairy cattle is not well established. Estimates range from as high as 50°F (NRC, 1981) to as low at -100°F (NRC, 2001). Regardless, there is evidence that the performance of lactating cows decreases at temperatures below 20°F (NRC, 1981). One clear effect of cold stress is an increase in feed intake. While increased feed intake often results in greater milk production, cold-induced feed intake is caused by an increase in the rate of digesta passage through the gastrointestinal tract. An increased passage rate limits the digestion time and results in less digestion as the temperature drops (NRC, 2001). In cold temperatures, cows also maintain body temperature by using nutrients for shivering or metabolic uncoupling, both of which increase maintenance energy costs. These two mechanisms decrease milk production by more than 20% in extreme cold stress. However, even when cold stress does not negatively impact productivity, decreased feed efficiency can hurt dairy profitability.

To assess the effects of environmental stress on feed efficiency and profitability, a model was constructed to incorporate temperature effects on dry matter intake, diet digestibility, maintenance requirements, and milk production. Expected responses of a cow producing 80 pounds of milk per day in a thermoneutral environment with total mixed ration (TMR) costs of $0.12/lb dry matter and milk value of $18/ hundred weight of milk (cwt) are shown in Figure 4. The model was also altered to assess responses to cold stress if milk production is not decreased. In this situation, the decrease in diet digestibility alone results in an 8% decrease in income over feed cost as temperatures drop to -10°F ($6.94 vs. $7.52/cow per day).

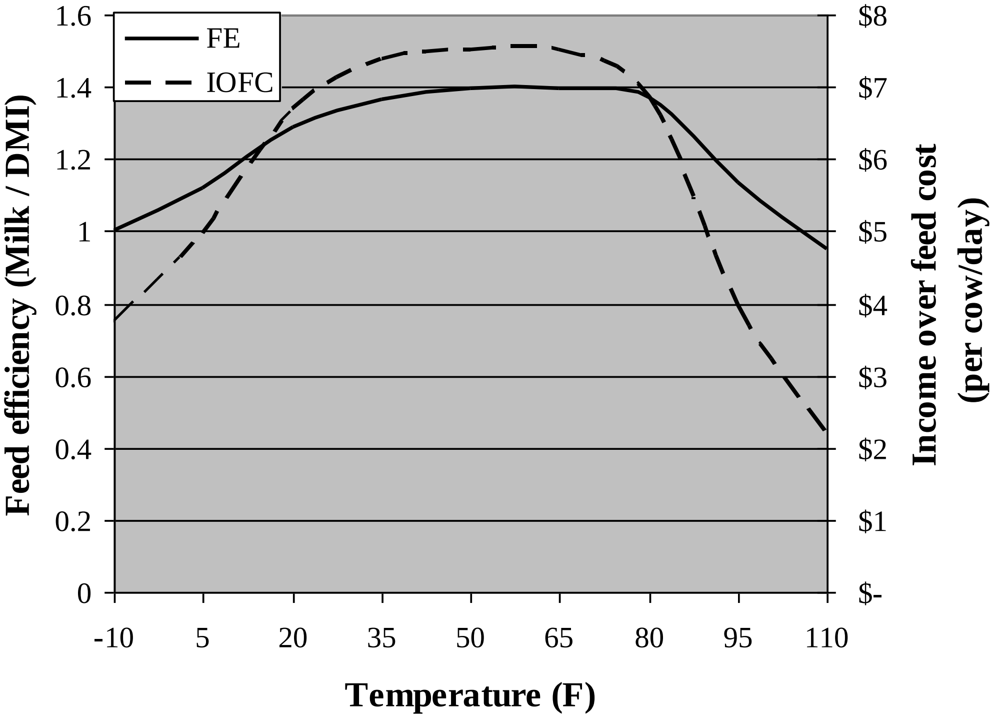

Figure 4. Responses to Environmental Stress, (Thermoneutral Production of 80 lbs/day, TMR Cost of $0.12/lb Dry Matter, and Milk Value of $18/cwt)

With these research results, cost benefits can be estimated for environmental control of LPCV facilities. Benefits of avoiding extreme temperatures can be evaluated by comparing returns at ambient temperatures to temperatures expected inside LPCV barns. For example, the model above predicts that income over feed cost can be improved by nearly $2 per cow/day if the ambient temperature is 95°F and barn temperatures are maintained at 85°F. Likewise, if ambient temperature is 5°F and the temperature inside the barn is 15°F, income over feed cost is expected to increase by $1.15 per cow/day.

Besides effects on feed costs and productivity, heat stress also has negative effects on reproduction, immunity, and metabolic health. These factors represent huge potential costs to a dairy operation. While responses to cold stress are not typically dramatic, increased manure production is a resulting factor. In this model, increased feed intake and decreased digestibility during cold stress also increased manure output by as much as 34%. This is a significant cost factor on many farms, requiring increased manure storage capacity and more acres for manure application.

Environmental Impact on Reproduction

Even though cold stress has little effect on reproduction, heat stress can reduce libido, fertility, and embryonic survival in dairy cattle. Environmental conditions above a dairy cow's thermoneutral zone decreases ability to dissipate heat and results in increased core body temperature. The elevated body temperatures negatively impact reproduction, both for the female and the male.

The impact of heat stress can be categorized by the effects of acute heat stress (short-term increases in body temperature above 103^{o} F) or chronic heat stress (the cumulative effects of prolonged exposure to heat throughout the summer). In acute heat stress, even short-term rises in body temperature can result in a 25 – 40% drop in conception rate. An increase of 0.9^{o} F in body temperature causes a decline in conception rate of 13% (Gwazdauskas et al.). The impact of heat stress on reproduction is more dramatic as milk production increases, due to the greater internal heat load produced because of more feed intake (al-Katanani et al., 1999).

Declines in fertility are due, at least in part, to damage of developing follicles that results in lower production of the follicular hormone estradiol. Also, poor quality ovulatory follicles transition into corpora lutea following ovulation. Corpora lutea are responsible for producing progesterone, a key hormone to the success of reproduction. As a consequence of reduced levels of estradiol and progestone, lower quality, aged follicles are ovulated and the resulting conception rate is decreased (Wolfenson, et al.). The lower estradiol levels also make it more difficult to find cows in heat, since a high level of estradiol is required for a cow to express heat or stand to be mounted. In herds that utilize artificial insemination (AI) and depend entirely on estrus detection, heat detection declines of at least 10-20% are common during the summer months. Timed AI tends to account for a greater percentage of inseminations during the summer months as a consequence of the difficulty in finding cows in heat.

If, despite the reduced follicular quality, cows manage to become pregnant, a greater likelihood exists of embryonic loss due to heat stress. Many times, cows actually achieve ovulation and fertilization, but early embryonic loss often occurs during days 2 to 6 post-insemination and the observer believes that the cow never actually conceived.

Chronic heat stress also negatively impacts follicular and corpora lutea quality and results in reduced estradiol and progesterone levels. One additional impact of chronic heat stress is an increased risk of twinning, especially for cows that become pregnant toward the latter periods of heat stress. The risk of late embryonic loss and abortion is approximately 2 to 2.5 times greater for cows bred during and immediately following heat stress. Chronic heat stress also greatly depresses feed intake and prolongs the period of time required for a cow to reach positive energy balance, thus causing excessive weight loss and delaying days to the first ovulation. Because of the severe challenges of impregnating cows during the summer, some herds decrease their efforts during this time.

Whether the decline in pregnancy rates is voluntary or not, drops in the number of cows that become pregnant create holes in the calving patterns. Often, there is a rebound in the number of cows that become pregnant in the fall. Nine months later, a large number of pregnant cows puts additional pressures on the transition facilities when an above-average group of cows moves through the close-up and fresh cow pens. Overcrowding these facilities leads to increases in post-calving health issues, decreased milk production, and impaired future reproduction.

Environmental Impact on Milk Production

Though the impact of cold stress on milk production is minimal, the impact of heat stress on milk production can be very dramatic. Numerous studies have been completed to evaluate the economic impact of heat stress on milk production (Dhuyvetter et al., 2000), but because so many approaches are used to manage heat stress, standard evaluations are difficult. Heat stress not only impacts milk production during summer months, but it also reduces the potential for future milk production of cows during the dry period and early lactation. For every pound of peak milk production that is lost, an additional 250 pounds of production will be lost over the entire lactation.

A simple sensitivity analysis was conducted to observe the impact of heat stress on gross income. A net milk price of $18/cwt was used for this analysis. The milk production impact of 90-150 days of heat stress on gross income and IOFC per cow is presented in Table 1. When daily milk production is reduced 2 to 12 pounds per day per cow, the gross income loss related to heat stress ranges from $32.40 to $324.00 per cow and IOFC from $22.80 to $228.00.

Table 1.

Reduction of milk production (lbs/cow/day)	Total Lost Production Days of Lost Production			Reduction in Gross Income Days in Lost Production			Total Reduced Feed (lbs) Days of Lost Production			Reduction in IOFC* Days in Lost Production		
	90	120	150	90	120	150	90	120	150	90	120	150
2	180	240	300	$32.40	$43.20	$54.00	80	107	133	$22.80	$30.40	$38.00
4	360	480	600	$64.80	$86.40	$108.00	160	213	267	$45.60	$60.80	$76.00
6	540	720	900	$97.20	$129.60	$162.00	240	320	400	$68.40	$91.20	$114.00
8	720	960	1200	$129.60	$172.80	$216.00	320	427	533	$91.20	$121.60	$152.00
10	900	1200	1500	$162.00	$216.00	$270.00	400	533	667	$114.00	$152.00	$190.00
12	1080	1440	1800	$194.40	$259.20	$324.00	480	640	800	$136.80	$182.40	$228.00

* Assumes feed efficiency remains constant

The impact of heat stress on future milk production is evaluated in Table 2. Gross income per cow per lactation is increased from $90 to $540 per cow/lactation and IOFC is increased from $63.33 to $380.00 as peak milk production is increased from 2 to 12 lbs/cow/day during periods of heat stress.

Table 2.

Increase in Peak Milk Production (lbs/cow/day)	Additional Milk Production (lbs/lactation)	Additional Gross Income (lbs/lactation)	Additional Feed (lbs) (lbs/lactation)	Increase in IOFC* (lbs/lactation)
2	500	$90.00	222	$63.33
4	1000	$180.00	444	$126.67
6	1500	$270.00	667	$190.00
8	2000	$360.00	889	$253.33
10	2500	$450.00	1111	$316.67
12	3000	$540.00	1333	$380.00

*Assumes feed efficiency remains constant

Commonly Asked Questions

As with any new concept or technology there are many questions that will be asked by dairy producers and their employees. The following are list of questions often asked about LPCV facilities.

1. How does the construction cost of naturally ventilated freestall facilities (NV) compare to cross ventilated freestalls (LPCV)? When you compare the two types of facilities do they have similar ability to cool cows, manage long day lighting, etc.?
2. In your experience, how does the feed efficiency and income over feed costs (IOFC) compare in NV and LPCV facilities?
3. How do you manage winter ventilation and at what temperature does it become difficult to manage?
4. Are you able to keep the alleys from freezing during the winter months?
5. Walking distance to the parlor in LPCV’s is reduced significantly, does this give you adequate time to remove manure, groom stalls, etc.?
6. What impact does changing the air temperature in a LPCV have on reproduction, milk production and health of cows during the summer months?
7. How often do you clean the fans?
8. If you use evaporative pads, how often do you clean the pads and how do you clean the pads?
9. What type of bedding do you use in the freestalls? Can you use organic bedding in LPCV’s?
10. How does the electrical cost in LPCV compare to NV facilities?
11. Are the maintenance costs of fans, baffles, doors, evaporative pads, lights and cleaning higher in LPCV facilities as compared to NV facilities?
12. How do you think NV and LPCV Facilities are perceived from an animal welfare prospective? Have you had questions about animal welfare?
13. Are flies easy to manage in LPCV facilities?
14. What do like and dislike about LPCV facilities?
15. If you could do it all over, what type of facility would you build?

Summary

LPCV facilities are capable of providing a consistent environment for dairy cows throughout the year. Changing the environment to reflect the thermoneutral zone of a dairy cow minimizes the impact of seasonal changes on milk production, reproduction, feed efficiency and income over feed cost. The key is to reduce variation in the core body temperature of the cows by providing a stable environment.

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