Heat abatement strategies during pre-weaning phase: Do they really improve the welfare and performance of Holstein calves?

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Introduction

The use of heat abatement strategies during the pre-weaning phase is seldom evaluated. Worldwide increase in environmental temperature, however, has become a concern for researchers and livestock industries because of its impact on profitability and welfare (St-Pierre et al., 2003; Gunn et al., 2019). High environmental temperature, humidity, radiation, and low wind speed may result in thermic stress. Across USA, 38% of dairy farms house calves outdoors (USDA, 2014) and little is known about their thermal comfort.

In an experiment conducted during the summer in the SE region of the USA, we determined whether 1) housing calves under a barn and 2) housing calves under a barn cooled through ceiling fans would increase growth and feed efficiency compared with housing calves outdoors. In addition, we evaluated the effects of ceiling fans on air quality, measured by reduce air ammonia (**NH_3**) concentration and bacterial counts.

Animals, Materials, and Methods

Male Holstein calves (n = 60) were assigned randomly to 1 of 3 treatments (Figure 1). Calves assigned to the control treatment (n = 20) were housed in individual frame-wire hutches, organized in a single line (east-west orientation), with 50% of its area covered by plywood. Calves assigned to the “shade” (**SH**) treatment (n = 21) were housed in individual hutches under a barn. Calves assigned to the “shade+fan” (**SHF**) treatment (n = 19) were housed in individual hutches under the same barn as the SH treatment and were provided fans (diameter = 6.9 ft, height = 13.5 ft from the ground, with blades directing the wind towards the hutches; VES Environmental Solutions, Chippewa Falls, WI). Frame-wire hutches were used for the SH and SHF treatments and they did not have plywood covering.

At birth (d 0), calves were weighed and, between 24 h to 48 h, serum total protein was determined. All calves were weighed (**BW**) and had the wither (**WH**) heights measured weekly. Study personnel measured feed intake of all calves daily. Milk intake was determined twice a day, at 0500 and 1700 h, by weighing left overs. Starting on d 14, calves were offered 0.44 lbs. of starter. At 1000 h, starter orts were determined using an electronic scale. When the starter orts were ≤ 0.04 lbs, the amount of starter offered increased by 0.13 lbs. Starting on d 50, when the starter orts were ≤ 0.04 lbs., the amount of starter offered increased by 1.10 lbs. Feed efficiency was calculated by dividing the average daily gain (**ADG**) by the dry matter intake within a week. The last measurements of BW and wither-height were performed on d 68.

The temperature and relative humidity were recorded using data loggers (HOBO U23 Pro v2 External Temperature Data Logger - U23-004; Bourne, MA) in order to calculate the temperature humidity index (**THI**). Six loggers, each placed inside a ventilated box, were distributed in the barn and three were distributed in the control treatment. Air velocity and temperature, concentration of NH_3, and bacteria counts were determined in a sub-set of hutches control, SH, and SHF treatments, respectively. At the same time air velocity and temperature were recorded, UF personnel determined the rectal temperature and respiratory frequency (visual counting of flank movement) of calves housed in these hutches.

Figure 1. Pictures from inside the barn in which SH and SHF treatments were applied and outside where the HS treatment was applied.

Results

Figure 2 depicts the weekly and hourly THI during the experiment. The mean (±SD) daily THI for the control, SH, and SHF treatments were 78.1 ± 1.4, 77.1 ± 0.9, and 77.2 ± 0.9, respectively. The SHF treatment increased air velocity by 85 to 198%, but the SH and SHF treatments reduced the air temperature by only 3 to 6% (Table 2) and THI by only 6% during the hottest parts of the day (1100 to 1500 h; Figure 2B). The relatively small effects of the SH and SHF treatments on air temperature and THI still were sufficient to reduce the rectal temperature of calves by 0.4 and 2 °F at 0900 and 1500 h, respectively (Table 2). In addition, calves in the control treatment had respiratory frequency approximately 40 mov/min greater than calves in the SH and SHF treatments.

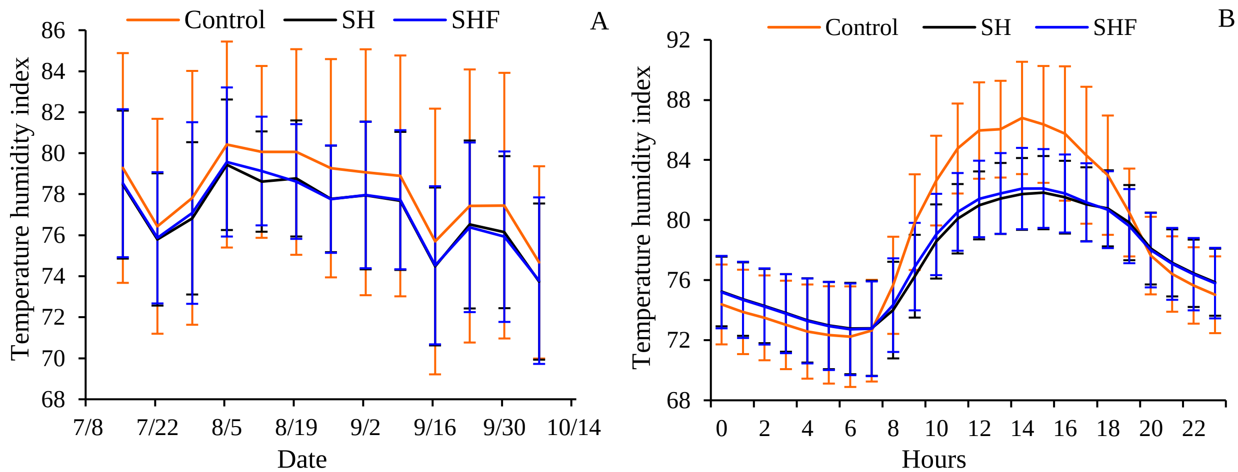

Figure 2. Data logger (HOBO U23 Pro v2 External Temperature Data Logger - U23-004; Bourne, MA) recorded weekly (A) temperature humidity index.

Table 1. Effect of treatment on air velocity and temperature inside the hutches and on rectal temperature and respiratory frequency.

Variable (±SEM)	Control	SH	SHF	*P*-value
		0900 h		
Air velocity, m/sec (±SEM)	0.58 ± 0.09[a,A]	0.42 ± 0.04[a,B]	1.25 ± 0.04[b]	< 0.01
Air temperature, °F (±SEM)	92.1 ± 0.01[a]	86.8 ± 0.01[b]	86.4 ± 0.01[c]	< 0.01
Rectal temperature, °F (±SEM)	101.8 ± 0.004[a]	101.7 ± 0.004[A]	101.4 ± 0.004[b,B]	0.02
Respiratory frequency, mov/min (±SEM)	78.6 ± 3.4[a]	39.2 ± 5.4[b]	37.4 ± 4.7[b]	< 0.01
		1500 h		
Air velocity, m/sec (±SEM)	0.66 ± 0.09[a]	0.44 ± 0.05[b]	1.22 ± 0.05[c]	< 0.01
Air temperature, °F (±SEM)	93.1 ± 0.01[a]	91.0 ± 0.01[b]	90.7 ± 0.01[b]	< 0.01
Rectal temperature, °F (±SEM)	104.1 ± 0.01[a]	102.3 ± 0.01[b]	102.1 ± 0.01[b]	< 0.01
Respiratory frequency, mov/min (±SEM)	96.0 ± 3.6[a]	42.4 ± 5.7[b]	35.8 ± 5.0[b]	< 0.01

[a,b] Means with different superscript differ ($P \leq 0.05$).
[A,B] Means with different superscript differ ($0.05 < P \leq 0.10$).

Surprisingly, we did not observe an effect of the SH and SHF treatments on daily intake of milk solids and starter. In line with the lack of differences in intake, we did not detect differences among treatments regarding ADG (control = 1.4 ± 0.09, SH = 1.3 ± 0.09, SHF = 1.3 ± 0.09 lbs/d) from birth to weaning and BW (control = 194.0 ± 3.8, SH = 189.4 ± 3.8, SHF = 187.8 ± 4.2 lbs) at weaning. At weaning, calves in the SHF treatment were 1 inch taller than calves in the

HS treatment, whereas SH treatment did not differ from both (control = 35.0 ± 0.3, SH = 35.4 ± 0.3, SHF = 36.0 ± 0.4 in). Although this is a small difference in height, which could be biologically unimportant, it could be a consequence of heat stress induced changes in post-absorptive nutrient partitioning. The effects of heat stress on post-absorptive nutrient partitioning in pre-weaned dairy calves is overlooked because BW, ADG, and feed efficiency are more important from an economic view point. In lactating cows, however, it has been established that only 36% of the reduction in milk yield during heat stress is explained by the decrease in dry matter intake. This has led to the theory that, under heat stress, nutrient prioritization shifts from milk production to other vital functions.

In our experiment, the SH treatment resulted in NH_3 concentration and bacteria count (e.g. total and Gram negative) ≥ 54% and ≥ 14% greater, respectively, on days 32 and 67 of age compared with HS and SHF (Table 2). The greater concentrations of NH_3 and bacteria count in the air at 32 and 67 d of age in the SH treatment indicate that the reduced air velocity in a naturally ventilated barn without fans may result in limited air exchange, resulting in greater build-up of NH_3 and bacteria in the air. Differences in NH_3 concentration and bacteria count in the air between the control and SHF treatments were smaller and less consistent, leading to the conclusion that, when housing calves inside a barn, the use of fans improves air quality making it comparable to air quality out in the open.

Table 2. Effect of treatment on ammonia concentration (**NH_3**) and bacteria count.

Variable (±SEM)	Control	SH	SHF	*P*-value
NH_3, ppm				
Day 32	0.262 ± 0.162^{A}	$0.861 \pm 0.175^{a,B}$	0.126 ± 0.066^{b}	< 0.01
Day 60	0.319 ± 0.156^{a}	2.321 ± 0.355^{b}	1.056 ± 0.215^{c}	< 0.01
Total bacteria count, CFU/m^3				
Day 35	$1,920.4 \pm 15.5^{a}$	$5,326.2 \pm 17.8^{b}$	$4,587.2 \pm 15.1^{c}$	< 0.01
Day 67	$5,758.0 \pm 31.5^{a}$	$9,562.3 \pm 24.0^{b}$	$5,134.2 \pm 16.3^{c}$	< 0.01
Gram negative count, CFU/m^3				
Day 35	544.0 ± 8.7^{a}	742.1 ± 6.6^{b}	385.5 ± 4.2^{c}	< 0.01
Day 67	576.9 ± 8.7^{a}	671.9 ± 6.2^{b}	301.7 ± 3.6^{c}	< 0.01

[a,b] Means with different superscript differ ($P \leq 0.05$).
[A,B] Means with different superscript differ ($0.05 < P \leq 0.10$).

Conclusions

Provision of fans to calves housed under a barn increased air velocity by nearly 3-fold, but it only reduced the air temperature by 2.1 to 5.7 °F. Thus, calves from all treatments were exposed to heat stress, which may be the reason why we did not detect differences among treatments on intake, ADG, feed efficiency, and BW. The difference in wither-height at weaning between the control and SHF treatments warrants further investigation to determine if it is biologically relevant. We speculate that this could be a consequence of heat stress induced changes in post-absorptive nutrient partitioning and/or bone metabolism, but these theories remain to be proved. Housing calves under a barn with or without the provision of fans improved thermoregulatory responses, measured by rectal temperature and respiratory frequency.

References

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