Climate Conditions in Bedded Confinement Buildings

Terry L. Mader
University of Nebraska-Lincoln, tmader1@unl.edu

Leslie J. Johnson
University of Nebraska-Lincoln, ljohnson13@Unl.edu

Sheryl L. Colgan
Animal Science, Haskell Agricultural Laboratory, Northeast Research and Extension Center, Concord, Nebraska

Climate Conditions in Bedded Confinement Buildings

Terry L. Mader
Leslie J. Johnson
Sheryl L. Colgan[1,2]

Summary

Climate conditions in bedded feedlot facilities during summer, fall, and winter seasons were measured. Summer season temperatures and THI levels were greatest at the front of the building. In winter, the building (with a curtain) maintained greater temperature, when compared to outside conditions, by decreasing wind speed through the building. Wind speeds through the building were reduced regardless of curtain usage.

Introduction

Confinement buildings are used for finishing cattle to allow more efficient collection of animal waste and to buffer animals against adverse climatic conditions. Buildings are typically naturally ventilated and positioned to take advantage of seasonal climatic conditions. In bedded units, bedding absorbs moisture and provides insulation as well as a softer surface for cattle. The objective of our study was to determine climate conditions in bedded feedlot facilities during summer, fall, and winter seasons.

Procedure

Data were obtained from a 1,044 ft long bedded confinement building with the long axis oriented east to west. The south side (front) is 28 ft high and the north (back) side is 16 ft high with 12 ft being open (at the top). The opening was closed to within 3 ft of the top in the winter using a curtain. The building is 96 ft wide with a 15 ft alley on the north side. Within the building, there are 8 pens that hold approximately 250 cattle each. Feedbunks are located on both north and south sides of the pen.

HOBO datalogger Procedure

Summer Trial — HOBO dataloggers (Onset, Pocasset, Mass.) were placed at the front and back sides of two bedded confinement pens. In addition, dataloggers were also placed on support columns in the middle of the pen and at the waterers, which are located midway between support columns and the front of the pen. Two dataloggers were also placed outside the building approximately 60 ft from the building.

Dataloggers were set to record temperature and relative humidity (RH) data starting at noon on June 20, 2006. They were removed on the morning of Aug. 10.

Winter Trial — HOBO Pro Series dataloggers were placed in two bedded confinement pens (same pens as summer trial). Dataloggers were set to record temperature and RH starting at 1500 on Jan. 9, 2007. They were removed on Jan. 17.

Kestrel Procedure

Fall and Winter Trials — Four Kestrel 4000 weather monitors (Nielsen-Kellerman Co., Boothwyn, Penn.) were placed in bedded confinement pens. Two monitors were placed on the front (high side) of the pen and two on the back (low) side of the pen. Monitors measured temperature, RH, and wind speed in the fall starting on Oct. 2, 2006, at 1500 and were removed the morning of Oct. 5 and in the winter from Jan. 9, 2007, at 1500 to the afternoon of Jan. 17.

General Procedures

For all seasons, dataloggers and monitors were approximately 7 ft from the ground. Weather data were also obtained from an automated weather station near Concord, Neb. approximately 7 miles from the confinement buildings.

The temperature humidity index (THI) was calculated for the summer and fall trials using the following equation:

THI = T-[0.55-{0.55*(RH/100)}]*(T-58)
where T = air temperature (ºF) and RH = relative humidity (%).

A THI value of less than 74 is considered normal. Threshold levels above 74 are defined as follows: 75-78 Alert; 79-83 Danger; 84+ Emergency.

In addition to weather data, pen surface temperatures were measured using an infrared gun at approximately 1500 during the fall trial in two confinement building pens and five outside feedlot pens in which no building was present.

Results

Air temperatures, RH, wind speeds, and indices from all trials are shown in Table 1.

Summer Trial — A period of high wind speed (primarily from the south and averaging 11.0 mph), and a period of low wind speed (primarily from the east-south-east and averaging 5.2 mph) were identified.

During the period of high wind speed, the average air temperature (Table 1) was similar in all locations except at the front of the building. The air temperature at the front of the building was greater than the temperature at the back of the building. This is probably due to the height of the front of the building, which allows for more direct exposure to sunlight as compared to the back of the building. Temperatures at the front of the building were greater during the day, but lower at night, and were actually cooler than the back of the building at 0600 (Figure 1). The average RH at the front of the building was greater than RH at the middle of the pen. Accumulation of moisture from cattle defecating and urinating while eating may create this difference. Hourly differences in RH between the front and back of the barn indicate RH was greater in the back of the building during daylight hours but then an opposite trend occurs at night. The

(Continued on next page)

average THI was similar across all locations during this period. In contrast to average data, hourly data shows that the THI was greater at the front of the building, when compared to the back of the building, during daylight hours only (Figure 2).

During the period of lower wind speed, similar temperatures (Table 1) were found outside the pen, at the waterer, the back of the pen, and the middle of the pen, but temperatures were greater at the front of the pen. Hourly differences between the front and back of the pen followed the same pattern as was found during periods of high wind with temperatures at the front of the pen being greater during most of the daylight hours due to the direct exposure to sunlight. Average RH during the low wind period were similar at the waterer, the middle of the pen and outside the confinement building. The RH at the back and the front of the building were greater than RH at the waterer and middle. Hourly RH data during this period indicated similar trends as found under the higher wind speed period. As discussed previously, the greater RH at the front and back may be due to the wetter manure/bedding accumulated behind the bunks versus the dryer bedding found in the middle of the pen. The THI during the lower wind period was the same in all locations excluding the front of the building. The THI at the front was greater due to elevated temperature and RH (Table 1). The THI at the front of the building was greater during 17 hours during the day, but was similar to THI at the back of the building during the nighttime hours from 0200 to 0800.

Fall Trial — Average air temperatures were different at each location. Temperatures were lowest outside and greatest at the front of the building (Table 1). Hourly air temperatures were found to be greater at the front of the building than at the back during the daylight hours, but no differences between front and back were observed during evening and night hours (Figure 3). Average RH were also different at all locations, with the front of the building having the lowest RH and outside being the greatest (Table 1). However,

Table 1. Results of summer, fall, and winter trials.

	Location					
	Outside	Front	Waterer	Middle	Back	SE
Summer 2006						
High Wind Speed (11.0 mph)						
Air Temperature, °F	88.4[ab]	89.9[b]	88.2[ab]	88.1[ab]	87.5[a]	1.0
Relative Humidity, %	50.1[ab]	54.4[b]	50.2[ab]	48.8[a]	53.4[ab]	2.4
THI[d]	79.1	80.6	79.3	79.0	79.5	0.9
Low Wind Speed (5.2 mph)						
Air Temperature, °F	81.7[a]	84.4[b]	82.3[a]	81.6[a]	81.5[a]	1.0
Relative Humidity, %	71.0[ab]	79.6[c]	69.6[a]	68.9[a]	74.6[b]	2.4
THI[d]	77.0[a]	80.0[b]	77.7[a]	77.0[a]	77.5[a]	0.9
Fall 2006[e]						
Air Temperature, °F	59.0[a]	61.2[c]	—	—	60.1[b]	0.4
Relative Humidity, %	74.0[c]	68.9[a]	—	—	71.4[b]	0.9
THI[d]	58.8[a]	60.6[b]	—	—	59.8[b]	0.4
Wind Speed, mph	8.9[c]	3.6[a]	—	—	5.8[b]	0.4
Wind Chill Index, °F[f]	57.4	62.0	—	—	59.8	5.3
Winter 2006-2007[e]						
Air Temperature, °F	6.1[a]	11.1[c]	12.2[c]	9.9[bc]	9.6[b]	0.7
Relative Humidity, %	79.8[ab]	82.5[c]	81.8[c]	79.1[a]	80.3[b]	0.6
Wind Speed, mph	14.9[b]	0.9[a]	—	—	1.1[a]	1.0
Wind Chill Index, °F[f]	-11.6[a]	12.4[c]	—	—	9.5[b]	0.7

[abc]Means within a row differ ($P < 0.05$).
[d]THI (Temperature Humidity Index) = $T_a - [0.55 - \{0.55 * (RH/100)\}] * (T_a - 58)$, where T_a = ambient temperature, °F and RH = relative humidity, %.
[e]Outside data were obtained from automated weather station located approximately 7 miles from feedlot site.
[f]Wind Chill Index = $35.74 + 0.6215 * T_a - 35.75 * WS^{0.16} + 0.4275 * T_a * WS^{0.16}$, where T_a = ambient temperature, °F and WS = wind speed, mph.

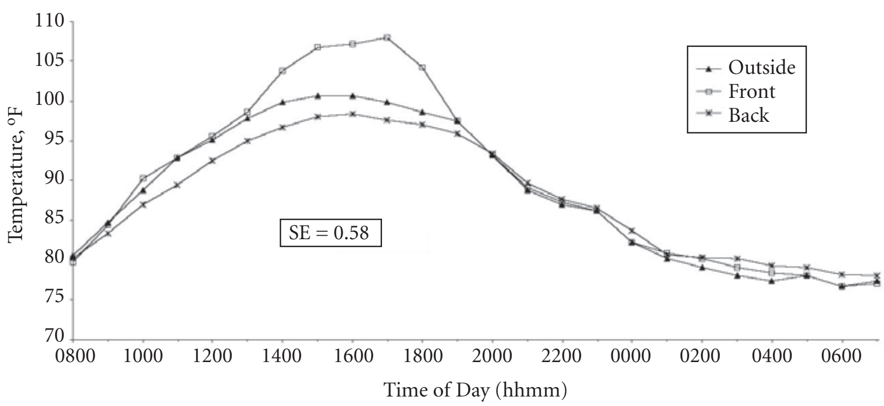

Figure 1. Summer 2006 air temperatures by hour during high wind conditions. Front vs. back were different from 1000 to 1900, at 0000, and at 0600. Outside vs. front and back were different at 1100, from 1500 to 1800, at 0300 and at 0400.

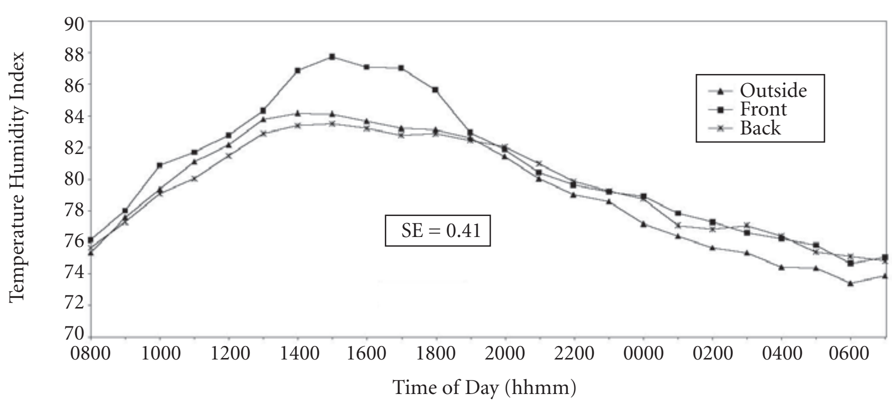

Figure 2. Summer 2006 temperature humidity index (THI) by hour during high wind conditions. Front vs. back were different from 1000 to 1800. Outside vs. front and back were different from 1400 to 1800 and from 0000 to 0700.

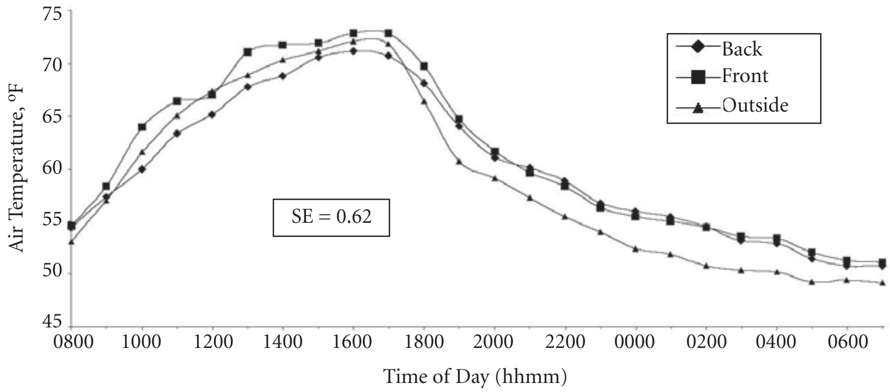

Figure 3. Fall 2006 air temperature by hour. Front vs. back were different from 1000 to 1400 and from 1600 to 1800. Outside vs. front and back were different at 0800 and from 1800 to 0700.

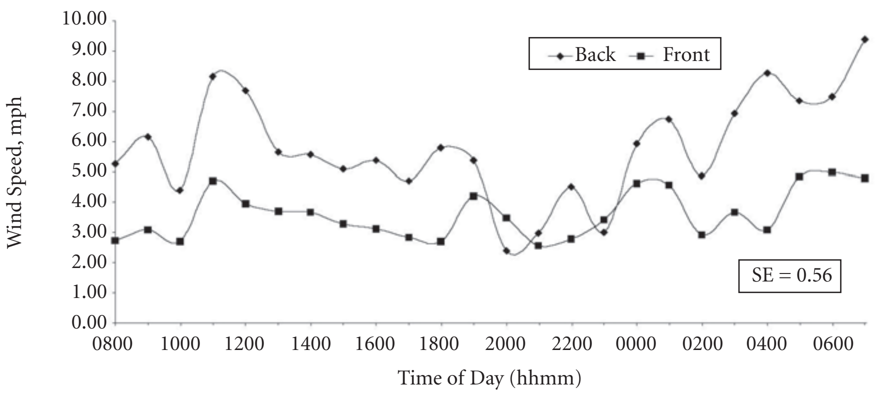

Figure 4. Fall 2006 wind speed by hour. Front vs. back were different from 0800 to 1800, at 2200, and from 0000 to 0700.

similar trends in hourly RH were found in the fall as those found in the summer with RH being lower at the front of the building during the daylight hours. No differences in RH were observed between the front and back of the building during the night hours. Average THI was similar within the building, but greater than those found outside (Table 1). Average wind speed differed at each location; it was greatest outside and lowest at the front of the building (Table 1). Hourly wind speeds were greater at the back of the building during most of the day (Figure 4).

Winds were most likely greater at the back of the building because of the funneling effect achieved by the design of the building resulting in the compression of air at the back of the building due to less open space when compared to the front. The average wind chill indices (WCI) during the fall trial were similar across all locations.

Infrared temperatures obtained during this time period indicated that pen surface temperatures at the front of the building were warmer than the back of the building, but were not as warm as the surface temperatures in outside pens (Table 2).

Table 2. Infrared temperatures of feedlot surfaces in two confinement building (CB) pens and five outside pens which contain cattle.

	Temperature, F	SE
Front of Pen (in sun)	98.3[b]	1.2
Back of Pen (shaded)	72.0[a]	2.7
Outside Pen	109.0[c]	3.7

[abc]Surface temperatures differ ($P < 0.05$).

Winter Trial — Average air temperatures during the winter trial were lowest outside the confinement pens (Table 1). The average temperatures at the middle of the pen were similar to both the back and the front of the pen, but the back temperature was lower than the waterer and the front of the building temperature. No significant differences were observed between the front and the back of the building at any hour. Average RH were greater at the front of the pen and at the waterer when compared to RH at other locations (Table 1). Relative humidity at the front of the pen was approximately 8 units greater at the front of the pen than at the back of the pen at 0900. Average wind speeds were similar within the building, but the outside wind speed was much greater (Table 1). No differences were found between the front of the building and the back, because the use of a curtain on the back side of the building diminished airflow through the pen when it was closed. The average WCI during the winter trial was different at each location (Table 1). The WCI was much lower outside than in the building but remained lower at the back of the building than the front. This is probably because of sun exposure elevating air temperatures at the front of the building, thus increasing the WCI.

In conclusion, low wind speed and/or decreased air movement associated with the building produced greater RH at the front of the building (south facing) in the summer and winter. The use of the buildings did not lessen heat stress in the summer, as measured by the THI, but acted as a solar shield (shade) and decreased solar heat load on the animal. In winter, when the north end of the building is nearly closed, via the use of a curtain, RH levels are elevated at the front of the building and at the waterer. However, temperatures in the building are elevated between 3.5 to over 6°F across the building.

Bedded barn facilities are useful for buffering cattle against the adverse effects of the environment under hot and cold conditions. In addition, if properly bedded, bedded barn facilities should virtually eliminate adverse effects that mud can have on cattle welfare and performance.

---

[1]Terry L. Mader, professor; Leslie J. Johnson, research technician; and Sheryl L. Colgan, research technician, Animal Science, Haskell Agricultural Laboratory, Northeast Research and Extension Center, Concord.

[2]The authors would like to express their appreciation to the Dixon County Feedyard, Allen, Neb., for the use of their facilities to conduct this study.