Evaluation of Heat Stress Abatement on Texas Dairy Farms

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INTRODUCTION

Heat stress is a major challenge important to the global dairy industry (Polsky and von Keyserlingk, 2017). In the US dairy industry alone, heat stress results in economic losses estimated at $900 million (St-Pierre et al., 2003). Heat stress is defined as the entirety of external forces (temperature, wind speed, etc.) acting on an animal that elicits an increase in body temperature (Dikmen and Hansen, 2009). Temperature humidity index (**THI**) considers ambient temperature and humidity to estimate the cooling requirements needed by cattle to improve the efficiency of management practices to dissipate heat. Cooling standards should start at a THI of 68 (Collier et al., 2011).

Heat stress can cause increased morbidity and mortality, negatively impact milk production (Renaudeau et al., 2012), and impair reproductive performance (Polsky and von Keyserlingk, 2017). De Rensis and Scaramuzzi (2003) reported the decrease in conception rates during warmer months to be between 20 and 30 %. West (2003) highlighted different studies that reported decreases in milk production upward of 0.32 kg (0.70 lb)/unit increase of THI.

Cooling options can occur based on the philosophies of convection, conduction, radiation, and evaporation (Polsky and von Keyserlingk, 2017). Fans help with convection cooling, sprinklers help with evaporative cooling, shade helps reduce solar radiation exposure, and stall base temperature can help with conduction cooling (Polsky and von Keyserlingk, 2017). Two disadvantages exist when employing evaporative cooling: large amounts of fresh water are used in cooling and large amounts of waste water must be properly managed (Polsky and von Keyserlingk, 2017). Modifying dairy cattle housing environments helps to reduce the adverse effects associated with heat stress (Beede and Collier, 1986). The objective of this study was to evaluate heat abatement systems on 3 different dairy farms in the High Plains region.

MATERIALS AND METHODS

Study farms

This study was conducted on 3 farms in the Texas panhandle 1 wk/mo from June 2017 to September 2017. Farm A utilized a cross ventilated barn for lactating cows with a freestall barn and dry lot for close-up and far off dry cows, respectively. Farm B utilized dry lot pens for both lactating and close-up dry cows, swamp coolers in the parlor, and holding pen cooling with soakers and fans. Farm C utilized dry lot pens for lactating cows with shades.

Vaginal temperature measurement

Vaginal temperature was recorded every 10 min using Thermochron iButtons (Embedded data systems, Lawrenceburg, KY). The Thermochron iButtons were placed into intravaginal devices (CIDRs, Zoetis) that lacked the progesterone either from being blank or being used twice

Table 1. Pens on each farm that housed a HOBO U23 Pro v2 External Temperature/Relative Humidity Data Logger - U23-001 (Onset, Bourne, MA)

Farm Letter	Pen Description
A	Inlet lactating cow pen Middle lactating cow pen Exhaust lactating cow pen Far-off dry cow dry lot pen Close-up dry cow freestall pen
B	Dry lot lactating cow pen
C	Dry lot lactating cow pen

previously to remove progesterone. The intravaginal devices were inserted into 10 cows/pen location on Monday morning and removed Friday morning of each study week.

Cattle demographics

Cow demographics information was obtained from Dairy Comp 305 (Valley Ag Software, Tulare, CA). Only pregnant, multiparous cattle were enrolled in the study. Milk yield for lactating cattle enrolled in the study was equal to or greater than whole farm average milk yield to ensure high yielding cattle were enrolled in the study.

Statistical analysis

All data analysis was performed in SAS (Version 9.4, SAS Institute, Inc. Cary, NC). Data points were removed if relative humidity equaled 0, vaginal temperatures were < 36° C, or vaginal temperature were > 42° C. The MEANS procedure of SAS was used to evaluate the means, minimums, and maximums of temperature, relative humidity, and THI for each pen. The inlet pen in the cross ventilated barn for farm A did not have any data recorded as the data logger was lost. The MIXED procedure of SAS was used to evaluate the fixed effects of pen, milk yield, and their 2-way interaction on vaginal temperature. Stepwise backward elimination was used to remove non-significant interactions ($P \geq 0.05$). Main effects were kept in the model regardless of significance. The MIXED procedure of SAS was also used to evaluate the fixed effects of pen, milk yield, and their 2-way interaction on vaginal temperature when outside THI was > 68. Stepwise backward elimination was used to remove non-significant interactions ($P \geq 0.05$). Main effects were kept in the model regardless of significance.

Table 2. Temperature, relative humidity, and temperature humidity index means (± SD)[1] for each pen on farm

Temperature mean ± SD	Relative humidity mean ± SD	Temperature humidity index mean ± SD	Pen	Farm
-	-	-	Inlet	A
71.80 ± 3.64	85.84 ± 6.44	70.71 ± 3.08	Middle	
73.17 ± 3.81	84.72 ± 5.87	71.88 ± 3.18	Exhaust	
76.38 ± 9.48	59.72 ± 19.46	71.59 ± 5.41	Far-off dry cow dry lot pen	
76.51 ± 9.08	60.73 ± 19.28	71.86 ± 5.42	Close-up dry cow Freestall pen	
76.50 ± 10.65	60.71 ± 20.69	71.63 ± 6.54	Dry lot	B
77.97 ± 9.82	60.29 ± 21.13	72.96 ± 5.92	Dry lot	C

[1]Ambient temperature and relative humidity was measured with a HOBO U23 Pro v2 External Temperature/Relative Humidity Data Logger - U23-001 (Onset, Bourne, MA) every 10 min. Temperature humidity index was computed using the following formula (NOAA and Administration 1976): THI = temperature (^{O}F) - [0.55 – (0.55 × relative humidity/100)] × [temperature (^{O}F) – 58.8].

Table 3. Temperature, relative humidity, and temperature humidity index[1] minimums and maximums for each pen on farm

Temperature minimum, °F	Temperature Maximum, °F	Relative humidity minimum	Relative humidity maximum	Temperature humidity index minimum	Temperature humidity index maximum	Pen	Farm
-	-	-	-	-	-	Inlet	A
64.20	80.80	58.30	97.36	63.89	76.30	Middle	
65.75	82.09	56.93	95.68	65.27	77.83	Exhaust	
55.26	98.23	26.98	99.61	55.58	82.73	Far-off dry cow dry lot pen	
56.83	95.95	26.94	97.66	56.56	81.81	Close-up dry cow Freestall pen	
53.03	99.96	26.69	100.00	53.42	84.10	Dry lot	B
55.17	99.96	26.95	100.00	55.55	83.81	Dry lot	C

[1]Ambient temperature and relative humidity was measured with a HOBO U23 Pro v2 External Temperature/Relative Humidity Data Logger - U23-001 (Onset, Bourne, MA) every 10 min. Temperature humidity index was computed using the following formula (NOAA and Administration 1976): THI = temperature (ºF) - [0.55 – (0.55 × relative humidity/100)] × [temperature (ºF) – 58.8].

RESULTS

Description of each farm and pen that cattle were housed in is depicted in Table 1. Means, minimum, and maximums for temperature, relative humidity and THI are depicted in table 2 and 3. Vaginal temperature least square means (± SE) for lactating and dry cows in each pen are displayed in Table 4 and 5, respectively. Lactating cows housed in the dry lot on Farm C had the greatest vaginal temperatures when compared to cows housed in different pens on Farm A and B. Within the cross ventilated barn, cattle housed in the pen near the exhaust had the greatest vaginal temperatures compared to the inlet and middle pens. Cows housed in a dry lot pen on farm B had the least vaginal temperatures compared to both Farm A and C. Cows housed on farm B were subject to cooling in the holding pen and parlor; where Farm C did not utilize cooling in the holding pen. The cows on farm B were milked at 6:30 a.m., 3:00 p.m. and 11:00 p.m.; thus this holding pen and parlor cooling may have been strategically timed to mitigate the effects of heat stress.

Table 4. Least squares means (± SE)[1] of vaginal temperatures[2] for each pen of lactating cattle

Vaginal Temperature, °C	Pen	Farm
39.03 ± 0.02[c]	Inlet	A
39.10 ± 0.03[bc]	Middle	
39.12 ± 0.03[b]	Exhaust	
38.97 ± 0.02[d]	Dry lot	B
39.33 ± 0.02[a]	Dry lot	C

[1]Least squares means (± SD) were evaluated using the MIXED procedure of SAS® (Version 9.3 SAS Institute, Inc., Cary, NC)
[2]Vaginal temperatures were measured every 10 min via Thermochron iButtons (Embedded data systems, Lawrenceburg, KY) placed into intravaginal devices, like CIDR's but lacking the progesterone either from being blank or being used twice previously to remove progesterone
[a,b,c,d] Pairs with different superscript letters ([a,b,c]) are significantly different ($P \leq 0.05$)

Table 5. Least squares means (± SE)[1] of vaginal temperatures[2] for each pen of dry cattle

Vaginal Temperature, °C	Pen	Farm
39.15 ± 0.02[b]	Far-off dry cow dry lot pen	A
39.41 ± 0.02[a]	Close-up dry cow Freestall pen	
39.16 ± 0.02[b]	Dry lot	B

[1]Least squares means (± SD) were evaluated using the MIXED procedure of SAS® (Version 9.3 SAS Institute, Inc., Cary, NC)
2Vaginal temperatures were measured every 10 min via Thermochron iButtons (Embedded data systems, Lawrenceburg, KY) placed into intravaginal devices, like CIDR's but lacking the progesterone either from being blank or being used twice previously to remove progesterone
[a,b] Pairs with different superscript letters ([a,b]) are significantly different ($P \leq 0.05$)

CONCLUSIONS

In conclusion, differences were observed in cattle housed in different housing options. Mean vaginal temperatures were greatest in a drylot pen with limited cooling. Cows housed in a dry lot pen may experience more heat stress due to less heat abatement strategies. However, when drylot cows received strategic cooling, vaginal temperatures were lowest. Additional investigations using cows matched for milk production need to be conducted to determine if this is a reflection of the increased heat increment associated with the higher milk production of cows in the cross-ventilated barn.

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