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Effect of Altered Feeding and Sprinkling on Performance and Body Temperature of Steers Finished in the Summer

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Sprinkling feedlot cattle to reduce heat stress improved overall feed conversion, reduced body temperature, and reduced water intake.

Summary

Effects of feeding time (800 vs 1400) and sprinkling on feedlot performance, body temperature, and mound microclimate were examined to determine their usefulness in reducing heat stress of feedlot steers. Feed conversion was improved overall for steers with access to sprinklers. Body temperature, early in the finishing period, was reduced by both sprinkling and afternoon feeding relative to steers fed at 800 h without access to sprinklers . Overall water intake was greater for steers fed at 800 without sprinkling than any other treatment.

Introduction

In the last decade, heat related production losses in Nebraska surpassed $100 million as a direct result of four heat waves in the years 1992, 1995, 1997 and 1999. In previous Nebraska Beef Reports (2001), we reported changes in body temperature and performance of steers subjected to either altered feeding regimens or water sprinkling, however additive benefits of these systems were not evaluated. Thus, this study was designed to examine altered feeding time with or without water sprinkling on body temperature and performance of feedlot steers.

Procedure

One hundred ninety-two crossbred (English x Continental) steers were received at the Northeast Research and Extension Center Feedlot, Concord, Neb. and processed according to normal procedures. Near the beginning of summer animals were weighed and randomly assigned to one of 24 pens (eight hd/pen). Treatments were assigned to pens using a factorial design, which

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consisted of feeding time (800 [AM] vs 1400 hours [PM]) and water sprinkling (none [DRY] vs sprinkling [WET]). Cattle on the PM feeding regimen were fed at 1400 hours and their bunks were managed such that there was no feed available to them between the hours of 800 - 1400. Sprinkling was accomplished via overhead sprinklers controlled by timers. Sprinkler placement allowed cattle to be sprinkled as well as adequately wetting the mound surface. Sprinklers operated 20 minutes every 1.5 hours between 1000 and 1730 on days when predicted maximum THI≥77. Predicted maximum THI was made using a linear relationship derived from data collected (July and August of previous two years) by a weather station in the center of the feeding facility. Linear relationships between maximum daily THI and THI at 0700, 0800, and 0900 hours were determined. Temperature-humidity index at 900 hours had the best relationship. The equation was programmed into a weather station located in the center of the facility. When THI at 900 hours was greater then or equal to 68, a solenoid connected to the water faucet supplying the sprinklers was opened, allowing the timer to operate the sprinklers.

All cattle were managed similarly from day 0 - 21 of the trial. During this time, no sprinkling was done and feed was delivered at 800 h. To obtain accurate baseline measurements all cattle were managed similarly (no sprinkling and 800 hour feeding).

Feed and water intakes were recorded daily. Body weights were obtained on days 0, 21, 56 and 83 (termination of the trial). On the morning of day 84, steers were transported to a commercial slaughter facility where hot carcass weight, marbling score, 12th rib fat thickness, liver abscess scores, and quality and yield grade were obtained. On days one - four, 31 - 35, and 58 - 63 tympanic temperatures (an indicator of core body temperature) were obtained from six hd/sprinkling-feeding time combination (TRT). Tympanic temperatures were obtained using Stowaway® XTI data loggers secured to the ear using tape and gauze. Thermistors attached to the data logger were inserted down the ear canal such that they were near the tympanic membrane. Temperature was recorded every 15 min and compiled into hourly readings. Microclimatic conditions (temperature and relative humidity) of the mound were monitored and recorded using HOBO Pro® data loggers. Loggers were attached at heights of 6 and 30 in to fence post that bisected the mounds. Loggers at 6 in. recorded ambient temperature and soil temperature at a depth of 1 in. via an attached probe. Ambient temperature and RH were recorded by the logger at 30 in., this allowed for THI to be calculated at this height.

Statistical analysis for performance, carcass, tympanic temperature and mound microclimate was done using General Linear Models procedures. The statistical model for performance data included feeding time, sprinkling, and feeding time x sprinkling with day 0 - 21 ADG being used as a covariant. Carcass data were analyzed similarly except no covariant was used. Tympanic temperature and mound microclimate data were analyzed using the repeated statement (to account for time of day) in SAS with the model including feeding time, sprinkling, and feeding time x sprinkling, day included in the model. Data were compared within time of day with $P < 0.05$ used to determine significance.

Results

Climatic conditions for days 21 - 83 are summarized in Table 1. Sprinklers operated on 31 of 63 days during the TRT period. Ninety percent of the days (28 of 31) the sprinklers operated, maximum THI was greater than or equal to 77. Temperature-humidity index exceeded 77 on 7 of the 32 non-sprinkling days of the treatment period. The equation used to predict maximum THI was accurate between 82 - 90% of the time.

During days 0 - 21, similar performance was found among TRT (Table 2). Also, for the 21 - 56 day performance, ADG, feed conversion, and DMI remained similar among TRT. However a feeding time x sprinkling interaction ($P < 0.05$) was found for water intake. Water intakes were 10 and 13% greater for AM/DRY steers than PM/DRY and PM/WET steers, respectively. For days 56 - 83 ADG and daily DMI remained unaffected by TRT and averaged 3.47 lb and 21.39 lb, respectively. Feed conversion during this time was affected by sprinkling ($P = 0.06$); steers in pens with sprinklers were 15 % more efficient than steers in pens without sprinklers. This difference resulted in an overall feed conversion improvement of 5% for steers in pens with sprinklers. Water intakes

Table 1. Climatic conditions during the 21 day common management and 63 day treatment period. Values represent the mean ± standard error.

Item	Mean	Maximum	Minimum
Days 0 - 21			
Temperature, °F	70.3 ± 1.6	81.3 ± 1.9	59.8 ± 1.4
Relative humidity, %	61.9 ± 2.6	82.8 ± 2.0	40.1 ± 3.0
THI[a]	66.9 ± 1.1	73.5 ± 1.0	59.5 ± 1.2
Days 22 - 56			
Temperature, °F	73.1 ± .9	82.4 ± 1.1	63.3 ± 1.0
Relative humidity, %	73.3 ± 1.0	90.0 ± .6	53.0 ± 1.7
THI[a]	70.4 ± .8	76.3 ± .8	62.9 ± .9
Days 57 - 83			
Temperature, °F	73.0 ± 1.0	82.9 ± 1.5	63.6 ± .9
Relative humidity, %	78.2 ± 1.5	92.6 ± .5	58.7 ± 2.8
THI	70.7 ± .8	77.0 ± 1.0	63.2 ± .8
Days 22 - 83			
Temperature, °F	73.0 ± .7	82.6 ± .9	63.4 ± .7
Relative humidity, %	75.4 ± .9	91.1 ± .4	55.3 ± 1.6
THI	70.5 ± .6	76.6 ± .6	63.0 ± .6

[a]THI = Temperature-Humidity Index = Temperature - (.55 - (.55 x (Relative humidity/100))) x (Temperature - 58)

Table 2. Effect of altered feeding time (800 [AM] vs 1400 [PM] h) with (WET) and without (DRY) sprinkling on feedlot performance of yearling steers.

Item	Treatments				
	AM/DRY	AM/WET	PM/DRY	PM/WET	SEM
Body weight, lbs					
Day 0	936.5	933.4	932.3	936.3	2.2
Day 21	1012.7	1009.4	1008.6	1012.5	2.2
Day 83	1239.1	1249.7	1236.0	1246.8	8.8
Average daily gain, lb/d					
Day 0 - 21[a]	3.83	3.53	3.75	3.42	.22
Day 22 - 83	3.64	3.86	3.64	3.79	.13
Dry matter intake, lb/d					
Day 0 - 21	20.21	20.03	19.88	20.98	.40
Day 22 - 83 21.38	20.94	20.94	21.31	.46	
Feed:gain					
Day 0 - 21	5.67	5.65	5.73	5.95	.15
Day 22 - 83[b]	5.89	5.45	5.78	5.64	.16
Water intake, gal/d					
Day 0 - 21	7.13	7.14	6.65	6.64	.74
Day 22 - 83[c]	10.03[d]	9.10[e]	8.97[e]	9.03[e]	.11

[a]Used as a covariate for subsequent performance (BW, gain, DMI and feed:gain) from days 22 - 83
[b]Sprinkling effect, P < .10
[c]Feeding time x Sprinkling interaction, P < .05
[de]Values within a row with different superscripts differ, P < .05

Table 3. Effect of feeding time (800 [AM] vs. 1400 [PM] h) with (WET) and without (DRY) sprinkling on carcass characteristics of yearling steers.

Item	Treatments				
	AM/DRY	AM/WET	PM/DRY	PM/WET	SEM
Hot carcass wt., lbs	771.0	768.5	766.6	761.7	4.4
Dress, %	62.1	61.6	61.9	61.3	.4
12th rib fat, in	.40	.47	.43	.44	.04
Yield grade	2.00	2.11	2.11	2.15	.08
1s and 2s, %	79.2	70.21	70.21	68.75	
Marbling score[ab]	550.6[c]	519.3[d]	505.5[d]	519.6[d]	10.5
Choice, %	75.0	57.5	63.8	66.7	

[a]Marbling score: 500 = Small 0 (low Choice)
[b]Feeding time x Sprinkling interaction (P < .05)
[cd]Values in a row with different superscripts differ (P < .05)

Table 4. Effect of feeding time (800 [AM] vs. 1400 [PM] h) with (WET) and without (DRY) sprinkling on tympanic temperature of yearling steers on days 30 - 32.

Time of day	Treatments			
0800	AM/DRY[a]	AM/WET[ab]	PM/DRY[b]	PM/WET[b]
0900 - 1400	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[b]
1500	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[a]
1600	AM/DRY[a]	AM/WET[c]	PM/DRY[bc]	PM/WET[ab]
1700 - 1900	AM/DRY[a]	AM/WET[c]	PM/DRY[bc]	PM/WET[b]
2000	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[ab]
2100	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[a]
2200 - 0200	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[ab]
0300	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[b]
0400	AM/DRY[a]	AM/WET[ab]	PM/DRY[b]	PM/WET[bc]
0500	AM/DRY[a]	AM/WET[a]	PM/DRY[b]	PM/WET[ab]
0600	AM/DRY[a]	AM/WET[ab]	PM/DRY[bc]	PM/WET[ab]
0700	AM/DRY[a]	AM/WET[bc]	PM/DRY[c]	PM/WET[ab]

[abc]Treatments in a row differ (P < .05)

for days 56 - 83 continued to be different in AM/DRY steers (feeding time x sprinkling, P < .05). These steers averaged 13% greater water intakes during days 56 - 83 and 11% greater overall. Other measures of performance remained unaffected by TRT.

Carcass traits of the TRTs are presented in Table 3. All TRTs had similar HCW, dressing percentage, QG, YG and fat thickness. However, marbling score was affected by a feeding time x sprinkling interaction (P < .05) with AM/DRY steers averaging 7% higher than all other steers.

Tympanic temperatures during the pre-TRT period (days 0 - 21) were not affected by TRT (data not shown), thus differences in subsequent TT measurements may be viewed as a direct result of TRT.

Tympanic temperatures on days 30 - 32 were affected by a Feeding time x Sprinkling x Time of day interaction (P < 0.05). Steers fed in the morning without access to sprinklers (AM/DRY) had higher TT than PM/DRY steers at all times sampled. Likewise, AM/DRY steers had higher (P < 0.05) TT than PM/WET at all times except 1500 - 1600 and 1900 - 200 h, and were higher (P < 0.05) than AM/WET steers at all times except 400 - 800 h. Differences between AM/WET, PM/DRY and PM/WET were minimal and variable and are best viewed by Table 4. With the exception of 800 h, cattle on TRTs designed to minimize heat stress had similar (P > 0.05) TT from 900 - 1400 h. On hour after feeding (1500 h) PM/WET steers had similar TT to AM/DRY, but both were higher than AM/WET and PM/DRY. These differences may be due to the fact that PM/WET steers were more comfortable because they had been sprinkled and had not experienced metabolic heat load associated with eating and therefore their increased TT may be attributed to an eating event.

Sprinkling x time of day interaction (P < 0.01) also affected TT on days 30 - 32 (Figure 2). During this time, TT of sprinkled steers was lower at 1400 and 1600 - 1900 h than non-sprinkled cattle. Maximum differences in TT of these animals was at 1800 h where DRY steers

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were 1°F higher than WET steers. These findings suggest provision of cattle with sprinklers moderated body temperature during the hottest part of the day, preventing them from being placed at risk for heat related production losses.

When TT were obtained later in the feeding period (days 61 - 62) there was a feeding time x time of day interaction (P < 0.001). Steers fed in the afternoon had higher TT than those fed in the morning between 1500 - 1900 h (Figure 2). These differences suggest PM steers had higher TT due to increased metabolic heat load associated with eating. Dry matter intakes of these steers during this time were not different (data not shown), however the time in which the AM steers consumed their meal may have altered their TT. These steers had numerically higher TT between 800 - 1100 h. This may be due to a shift in eating pattern such that a larger percentage of their diet was consumed at night. If this is the case, this would be a self-imposed, adaptive mechanism by these steers. Steers fed in the afternoon on the other hand would have been previously conditioned and adapted to consuming feed in the middle of the day. So although they did have higher TT, this may not be indicative of greater heat stress.

Mound soil temperature as collected on days 31 - 33 are presented in Table 5. Sprinkling lowered overall soil temperature (P < 0.001) at all times sampled (sprinkling x time of day interaction, P < 0.01). Differences between WET and DRY soil temperatures were minimized on days 30 - 32 at 730 h. At this time soil temperatures were 5.8°F lower (P < .05) for WET vs DRY mounds. Differences in soil temperature between WET and DRY mounds were maximized at 1730 hours where WET mounds were 12.9°F cooler (P < 0.05) than DRY mounds. The opportunity for conductive heat exchange between the soil and animal depends on the temperature differential. Thus, wet mounds would be more conducive for conductive cooling for the animal.

Temperatures at 6 and 30 inches above the mound on days 30 - 32 (Table 5) were also affected by sprinkling (P < 0.01) and a sprinkling x time of day interaction (P < 0.01). No differences were observed at 730 hours at either 6 or 30 inches above the mound, however at 1000 hours, temperatures at 6 and 30 inches above WET mounds were 3.8 and 1.8°F cooler (P < 0.05), respectively. Temperatures 6 inches above WET mounds remained 4.6, 5.2, 4, and 1.2°F cooler than DRY mounds at 1230, 1500, 1730, and 2000 hours, respectively. While temperatures 30 inches above the mound were 3.3, 3.2, and 1.8°F cooler (P < 0.05) than DRY mounds at 1230, 1500 and 1730 hours, respectively. Differences in RH 30 inches above the mounds on days 30 - 32 were evident between 730 - 1730 h (sprinkling x time of day, P < .05). Differences (P < .05)

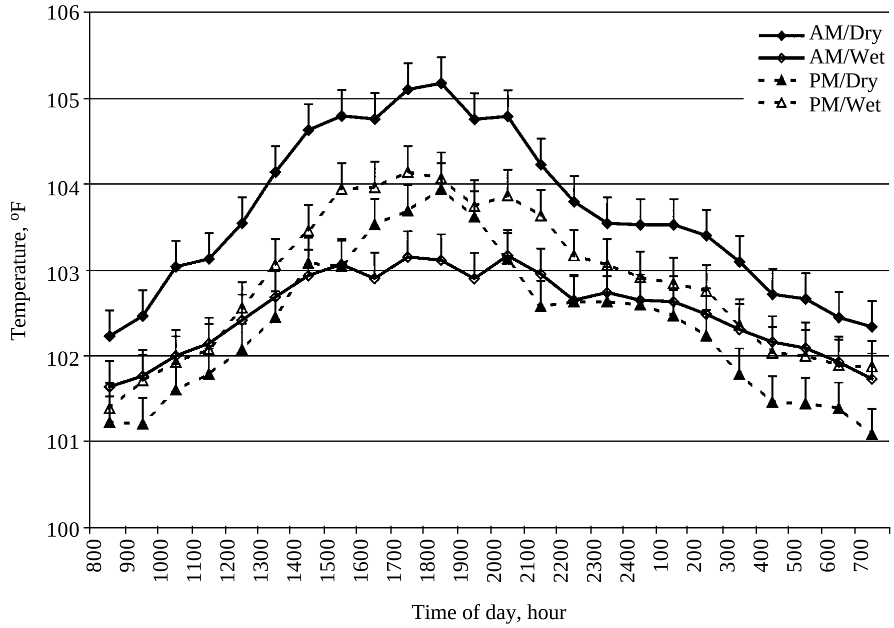

Figure 1. Effect of altered feeding regime (AM vs PM) and sprinkling (WET vs DRY) on tympanic temperatures of stress on days 31 - 33. Feeding time x sprinkling x time of day interaction (P<.05).

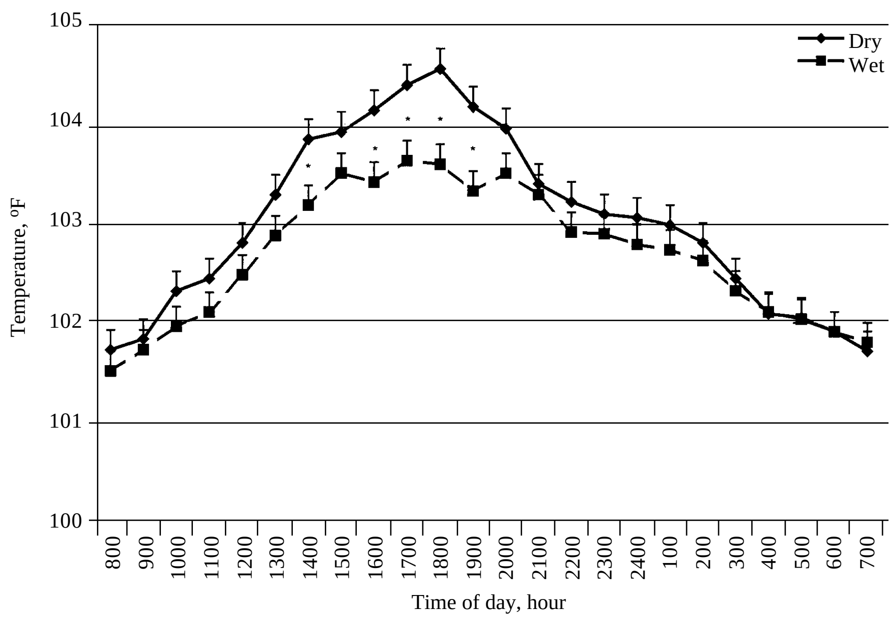

Figure 2. Effect of sprinkling on tympanic temperature of stress on days 31 - 33. Sprinkling x time interaction (P<.01). *Values within a time differ (P<.05).

Table 5. Effect of sprinkling on microclimatic conditions of the mound during days 30 - 32. Values represent least square mean ± standard error.

Item	Time of day, h					
	730	1000	1230	1500	1730	2000
Temperature, °F						
Soil[a]						
DRY	78.1 ± .4[b]	84.0 ± .5[b]	91.1 ± .7[b]	93.1 ± .7[b]	95.0 ± .6[b]	91.6 ± .4[b]
WET	72.3 ± .4[c]	77.7 ± .5[c]	83.0 ± .7[c]	82.3 ± .7[c]	82.1 ± .6[c]	80.0 ± .4[c]
6 inches[a]						
DRY	75.5 ± .4	84.2 ± .5[b]	91.5 ± .7[b]	92.8 ± .7[b]	91.6 ± .6[b]	85.7 ± .4[b]
WET	75.1 ± .4	80.4 ± .5[c]	86.9 ± .7[c]	87.6 ± .7[c]	87.6 ± .6[c]	84.5 ± .4[c]
30 inches[a]						
DRY	74.8 ± .4	83.1 ± .5[b]	90.6 ± .7[b]	91.8 ± .7[b]	90.3 ± .6[b]	85.3 ± .4
WET	74.4 ± .4	81.3 ± .5[c]	87.3 ± .7[c]	88.6 ± .7[c]	88.1 ± .6[c]	84.8 ± .4
Relative humidity, %						
30 inches[a]						
DRY	85.4 ± 1.1[b]	68.9 ± .6[b]	55.9 ± 1.4[b]	54.9 ± 1.2[b]	58.6 ± 1.4[b]	71.5 ± 1.2
WET	88.6 ± 1.1[c]	75.9 ± .6[c]	64.6 ± 1.4[c]	64.6 ± 1.2[c]	66.4 ± 1.4[c]	74.0 ± 1.2
Temperature-humidity index[d]						
30 inches[a]						
DRY	73.3 ± .2	78.7 ± .2[b]	82.4 ± .2[b]	83.2 ± .2[b]	82.7 ± .2	80.9 ± .1
WET	73.3 ± .2	78.1 ± .2[c]	81.4 ± .2[c]	82.4 ± .2[c]	82.3 ± .2	80.8 ± .1

[a]Sprinkling effect (P < .01)
[bc]Means within a parameter, position, and time with different superscripts differ (P < .05)
[d]THI = Temperature-Humidity Index = Temperature - (.55 - (.55 x (Relative humidity/100))) x (Temperature - 58)

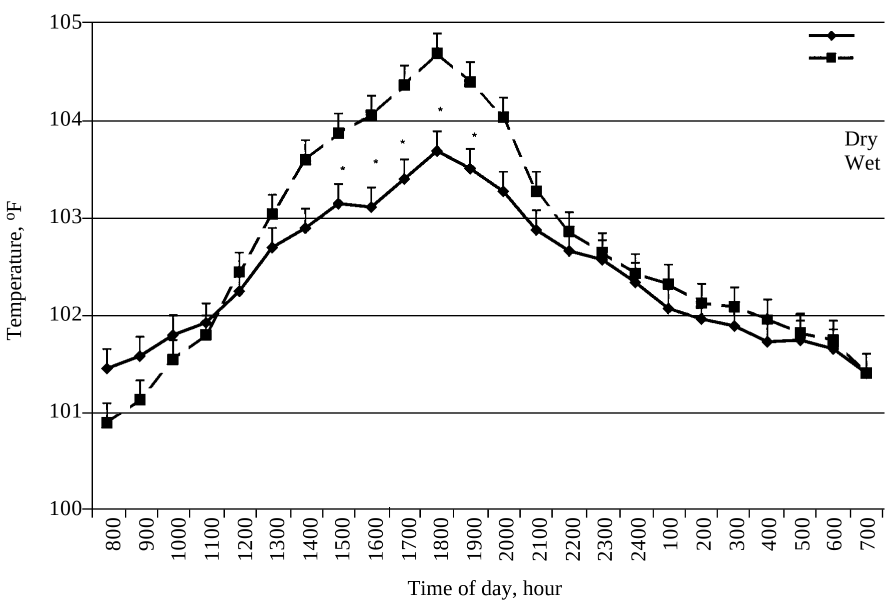

Figure 3. Effect of altered feeding time on tympanic temperature of steers on days 61 - 62. Feeding time x time interactino (P<.001). *Value within a time differ (P<.05).

across these times averaged 12% and ranged from 4% at 730 h to 18% at 1500 h. Despite increasing RH, THI was lowered (P < .05) in response to sprinkling. At 1000, 1230, and 1500 h, THI was lower (sprinkling x time of day, P < .05) 30 inches above WET mounds. Increased relative humidity accompanied by sprinkling can theoretically reduce the evaporative heat exchange mechanisms of the steers. However, the associated decreases in soil and ambient temperature would allow for greater animal comfort as well as increased conductive heat exchange. The decrease in body temperature observed in this study associated with sprinkling supports this theory.

Microclimatic conditions of the mounds obtained on days 30 - 32 and 61 - 62 (data not shown), collectively suggest that sprinkling alters the microclimatic profile of the sprinkled area making it conducive to greater heat flow away from the animal during hot environmental conditions. Although sprinkling did increase RH, animal comfort, as defined by THI, was improved in areas that were sprinkled. Both sprinkling and altering feeding time can decrease susceptibility of feedlot cattle to heat stress by lowering body temperature. Sprinkling cattle increases overall animal performance.

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