

Effects of Selected Weather Factors on Feed Intake of Angus, Polled Hereford, and Simmental Beef Bulls During Feedlot Performance Tests

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Story in Brief

Weather data were analyzed to more closely define the relationship between climate and feed intake of 3 breeds of beef bulls during feedlot performance tests. Intake data originated from Angus (n = 282), Polled Hereford (n = 440) and Simmental (n = 372) bulls in University of Arkansas Cooperative Bull Tests at Fayetteville, Hope, and Monticello. Principal component (PC) analysis initially was utilized to reduce the number of independent variables in the regression and overcome collinearity concerns associated with numerous weather-related variables. The set of selected variables in the final regression resulted from PC analysis on a much larger initial set of weather variables where many variables were eliminated. Coefficients of regression for the selected weather variables ranged from positive to negative depending on feeding period and breed. No single weather-related variable had a consistent effect (positive or negative) throughout all 5 periods across all 3 breeds; although the effect of barometric pressure was positive in all periods for Polled Hereford and Simmental bulls. While temperature is the most widely investigated climate variable, our results indicate lesser-researched climate variables (day length, rainfall, relative humidity, barometric pressure, and wind speed) each have their own individual effects on feed intake, in addition to their modifying effects on temperature. Individual breeds of beef cattle are affected differently by weather conditions and effect on feed intake differs as feeding period progresses.

Introduction

Genetic selection and breed choice are used by the beef cattle industry to alter growth in cattle. Because weight gain is dependent on nutritional intake, it is advantageous for all breeds to maintain a consistently high feed intake throughout a feeding period. However, weather-related effects on the animal can contribute to intake variation. Of known meteorological effects on beef cattle, none is more thoroughly documented than temperature, having been reviewed extensively. Behavioral responses to climate conditions are also well documented. Acute cold stress decreased forage intake by as much as 47 percent in grazing cattle (Adams, 1987). Feed intake by confined beef cattle fed finishing diets did not generally increase during cold stress and was often less during winter than during other seasons (Stanton, 1995). Temperature, environmental conditions, day length, animal, and perhaps management differences contribute to seasonal intake patterns, and separate effects are difficult to delineate. Reports indicate efficiency of beef production is related to breed, animal size, and age. Our objective was to more precisely define the relationship between feed intake and selected environmental factors on 3 breeds of performance-tested beef bulls.

Experimental Procedures

Feed intake data originated from Angus, Polled Hereford, and Simmental bulls (n = 1,094) evaluated in 52 individual 140-d University of Arkansas Cooperative Bull Tests at Fayetteville, Hope, and Monticello. A detailed description of test procedures and the ration fed is given in a companion paper (Tabler et al., 2007).

Photoperiod and Weather Data. Photoperiod information was obtained from sunrise/sunset tables (U.S. Naval Observatory,

Washington, D.C.). Weather data were obtained from the National Climatic Data Center (Asheville, N.C.). Weather variables used in the final analysis included: maximum temperature, day length, rainfall, relative humidity, barometric pressure, and wind speed.

Statistical analysis. Feed intake data from 52 post-weaning feedlot performance tests at 3 Arkansas locations over 13 yr were pooled and divided into five 28-d periods beginning with the start of each test, with each period and breed analyzed separately, using all animals over all tests. Statistical analyses were carried out using SAS Version 8.2 (SAS Institute, Inc., Cary, N.C.).

Weather variables considered to describe feed intake for each period were maximum temperature, day length, rainfall, relative humidity, barometric pressure, and wind speed. Principal component analysis eliminated all but this reduced set of variables from a much larger initial set of weather variables. All variables were standardized to a mean zero and a variance of one and product terms were calculated from the standardized variables before the principal components were determined. Distribution of bulls by breed and location of test is presented in Table 1. Because weather variables tended to be highly collinear, the regression of feed intake on them would be problematic. To avoid these issues, principal components (PCs) were calculated from the standardized original variables.

Environmental variables, eigenvalues and significance levels associated with each PC for each period on trial for Angus (n = 282), Polled Hereford (n = 440) and Simmental (n = 372) bulls in University of Arkansas Cooperative Bull Tests at Fayetteville, Hope and Monticello are presented in Tables 2 through 4, respectively. Among the principal components with eigenvalues greater than 1.0 (important in explaining common variance among the variables) and therefore, worthy of further consideration, 6 weather variables were dominant influences and these 6 were used in the final regression. Principal components with eigenvalues less than 1.0 were not considered in further analyses.

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In the final step, with information provided from PC analysis, feed intake was regressed on the initial set of variables using the PLS procedure of SAS. Regression coefficients for 6 environmental variables not eliminated by principal component analysis (maximum temperature, day length, rainfall, relative humidity, barometric pressure, and wind speed) are reported and discussed.

Results and Discussion

Coefficients of regression for the effects of maximum temperature, day length, rainfall, relative humidity, barometric pressure, and wind speed on feed intake of individually fed Angus, Polled Hereford, and Simmental beef bulls in feedlot performance tests are presented in Tables 5 through 7, respectively.

Coefficients of regression for the effects of maximum temperature on feed intake of Angus bulls were -7.17, 2.15, 6.91, -17.52, and -1.68 in periods 1 through 5, respectively. Polled Hereford bulls had coefficients of regression for effects of maximum temperature on feed intake of -5.56, 10.09, -4.25, 4.04, and -7.02 while Simmental bulls had coefficients of 15.03, -21.90, -12.55, 20.95, and 4.67 in periods 1 through 5, respectively. Both positive and negative coefficients for each of the 3 breeds indicate that the effect of maximum temperature on feed intake was not consistent over the entire trial, but instead, varied among the feeding periods and the 3 breeds.

Regression coefficients for the effects of day length on feed intake of Angus bulls were -5.03, 6.26, 6.07, -13.81, and -0.91 in periods 1 through 5, respectively. Coefficients of regression for effects of day length for Polled Hereford bulls were -6.22, 10.28, 7.82, -7.65, and 6.54 and 20.68, 52.32, 35.64, 1.39, and -0.90 for Simmental bulls in periods 1 through 5, respectively. This indicates that different breeds may respond either differently or the same to effects of day length at various stages in a feeding period.

Coefficients of regression for effects of rainfall on feed intake of Angus bulls were 0.66, 3.45, -1.76, 16.03, and -8.05 in periods 1 through 5, respectively. Regression coefficients for effects of rainfall for Polled Hereford bulls were -0.53, -1.53, -11.85, -12.83, and 8.84 and -8.07, 3.45, -8.53, -5.39, and -0.54 for Simmental bulls in periods 1 through 5, respectively. Again, there was not a consistent effect across all 5 periods for any breed; although, Polled Hereford and Simmental breeds did exhibit negative coefficients in 4 of the 5 periods. Indications were that, for Polled Hereford (periods 1 through 4) and Simmental (periods 1, 3, 4, and 5) breeds, as rainfall increased in 4 of 5 periods, feed intake decreased. In contrast, for Angus animals, as rainfall increased in periods 1, 2, and 4, feed intake also increased.

Regression coefficients for effects of relative humidity of feed intake for Angus bulls were 11.59, -6.50, -9.77, -4.80, and -3.73 in periods 1 through 5, respectively. Coefficients of regression for effects of relative humidity for Polled Hereford bulls were 7.95, -4.85, -7.64, 150.28, and -9.32 and 28.09, 2.85, 13.62, -4.31, and -12.18 for Simmental bulls in periods 1 through 5, respectively. For Angus animals, this indicates that feed intake increased in period 1 as relative humidity increased but feed intake decreased in periods 2 through 5 as relative humidity increased. Feed intake for Polled Hereford bulls increased in periods 1 and 4 and decreased in periods 2, 3, and 5 as relative humidity increased. For Simmental bulls, regression coefficients indicate that feed intake increased through the first part of the trial (periods 1, 2, and 3) as relative humidity increased but decreased in periods 4 and 5 as humidity increased. Coefficients of regression for effects of barometric pressure were

positive in all 5 feeding periods for both Polled Hereford and Simmental breeds. For the Angus breed, coefficients were negative in 4 of the 5 periods. Regression coefficients for effects of barometric pressure on feed intake for the Angus breed were -12.38, -5.53, -4.27, -1.69, and 4.41 for periods 1 through 5, respectively. Coefficients of regression for effects of barometric pressure for Polled Hereford bulls were 3.99, 11.32, 13.87, 21.87, and 11.17 and 1.45, 19.78, 32.77, 29.02, and 9.17 for Simmental bulls in periods 1 through 5, respectively. This indicates that, for Polled Hereford and Simmental animals, as barometric pressure increased, feed intake also increased in each of the 5 feeding periods. In contrast, for Angus animals, as barometric pressure increased, feed intake decreased in 4 of 5 periods.

Coefficients of regression for effects of wind speed on feed intake of Angus bulls were 3.10, 8.30, 6.07, -0.71, and -13.86 in periods 1 through 5, respectively. Regression coefficients for effects of wind speed for Polled Hereford bulls were -4.86, -2.85, 1.08, 12.78, and 6.45 and 27.00, 9.95, 21.85, 4.95, and -14.90 for Simmental bulls in periods 1 through 5, respectively. This indicates that feed intake increased in the early part of the trial (periods 1 through 3) and decreased in periods 4 and 5 as wind speed increased for Angus bulls. In contrast, feed intake decreased in periods 1 and 2 and increased in periods 3, 4, and 5 as wind speed increased for Polled Hereford bulls. For Simmental bulls, positive coefficients in periods 1 through 4 indicate that feed intake increased as wind speed increased while a negative coefficient in period 5 indicates feed intake decreased as wind speed increased during this period.

The NRC (1987) noted possible breed-specific effects and indicated that genetic selection for feed efficiency could produce animals with increased feed intake potential, suggesting that genetic potential for growth (or increased production demands) may affect feed intake. Intake differences among beef cattle breeds and their crosses may largely be accounted for by differences in mature size (NRC, 1987). However, environmental conditions likely affect feed intake among different breeds differently and breed differences have not been clearly identified. Genetic differences require further research but even less well-understood are differences between individual animals of the same breed or genetic background.

The numerous breeds of cattle used in beef production systems today represent many diverse biological types that likely perform differently in a given environment. Variations in frame size, coat color and genotype can lead to differing levels of feed intake in response to environmental conditions. Feedlot cattle include both beef and dairy breeds fed for slaughter and both are generally considered to have similar nutrient requirements at equivalent empty body weights (Schwartzkopf-Genswein et al., 2003). However, environmental variables may affect breeds differently due to differences in body composition and hair coats. Skin thickness, hair coat, rumen volume, rate of digestion, and metabolic efficiency all differ among breeds (Dean et al., 1976), and could affect behavioral responses to environmental conditions and management practices. Schwartzkopf-Genswein et al. (2003) reported the effects of air temperature, relative humidity and barometric pressure on feed bunk attendance were more pronounced with Charolais than with Holstein steers. While these differences were not reflected in performance, they do suggest that behavioral responses to the environment may be breed related.

Mader et al. (2002) indicated that, under hot (mean daily thermal heat index > 74) conditions, dark colored cattle tended to bunch more and pant more than light colored cattle and mean tympanic temperature measured 0.2 to 0.6°C greater for dark- vs. light-colored cattle. This supported the findings of Finch et al.

(1984). Arp et al. (1983) found that black-haired steers in commercial feedlots had body surface temperatures as much as 21°C greater than white-haired contemporaries while Finch et al. (1984) reported that rectal temperature averaged 0.3°C higher in dark-red vs. white *Bos taurus* cattle. Further documenting growth and performance responses of various cattle breeds to climatic conditions would provide valuable insight into management strategies for feeding different breeds.

Implications

Results indicate numerous climate factors influence feed intake. Further research is needed to better understand how individual weather factors affect feed intake of specific breeds (and individual animals); this will allow producers to better determine the proper mix among cattle breeds to place in various beef production locations.

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Table 1. Distribution of Angus, Polled Hereford, and Simmental bulls by breed and location of test.

Location ^a	Breed of bull		
	Angus	Polled Hereford	Simmental
Fayetteville	129	334	53
Hope 1	82	40	82
Hope 2	63	22	148
Monticello	8	44	89
TOTAL	282	440	372

^aLocation: Hope 1 = Hope Feb test; Hope 2 = Hope Aug test.

Table 2. Environmental variables¹, eigenvalues, and (significance levels) of selected principal components for each period on trial for Angus breed.

PC	Period on trial				
	1	2	3	4	5
1	MT, DL 6.49 (<0.001)	MT, DL 5.75 (<0.001)	MT, DL 5.79 (<0.001)	MT,DL 5.78 (<0.001)	MT,DL 5.94 (<0.001)
2	RH, Rain 1.74 (<0.001)	Rain 1.72 (<0.001)	Rain 1.78 (<0.001)	Rain 2.06 (<0.001)	WS 2.17 (<0.001)
3 ^a	-	Rain 1.45 (<0.001)	-	RH 1.64 (0.681)	RH, Rain 1.95 (<0.001)
4 ^a	-	Rain, WS 1.25 (<0.001)	-	BP, Rain 1.26 (<0.001)	MT 1.31 (<0.001)

¹MT = maximum temperature; DL = day length; BP = barometric pressure; Rain = rainfall; RH = relative humidity; WS = wind speed.

^aPeriods with no data indicate that PC was significant for animal initial weight and/or initial age but not for an environmental variable.

Table 3. Environmental variables¹, eigenvalues, and (significance levels) of selected principal components for each period on trial for Polled Hereford breed.

PC	Period on trial				
	1	2	3	4	5
1	MT, DL 6.39 (<0.001)	MT, DL 5.56 (<0.001)	MT, DL 5.81 (<0.001)	MT, DL 5.74 (<0.001)	MT, DL 5.29 (<0.001)
2	RH, Rain 1.84 (0.003)	WS 1.73 (<0.001)	WS 1.37 (<0.001)	RH, Rain 1.76 (<0.001)	RH, Rain 2.15 (0.015)
3	Rain 1.35 (<0.001)	RH, Rain 1.69 (<0.001)	Rain 1.34 (<0.001)	Rain 1.53 (0.002)	BP, Rain 1.71 (<0.001)
4 ^a	WS 1.09 (0.069)	-	-	-	RH 1.29 (<0.001)
5 ^a	-	-	Rain, WS 1.13 (0.123)	-	BP 1.17 (<0.001)

¹MT = maximum temperature; DL = day length; BP = barometric pressure; Rain = rainfall; RH = relative humidity; WS = wind speed.

^aPeriods with no data indicate that PC was significant for animal initial weight and/or initial age but not for an environmental variable.

Table 4. Environmental variables¹, eigenvalues, and (significance levels) of selected principal components for each period on trial for Simmental breed.

PC	Period on trial				
	1	2	3	4	5
1	MT, DL 5.76 (0.934)	MT, DL 5.33 (<0.001)	MT, DL 5.14 (<0.001)	MT, DL 5.41 (<0.001)	MT, DL 5.78 (0.057)
2	RH, Rain 1.76 (0.593)	Rain 1.88 (0.989)	BP, WS 1.85 (0.353)	RH, Rain, WS 1.61 (<0.001)	Rain 1.88 (<0.001)
3 ^a	RH, Rain 1.62 (<0.001)	RH, WS 1.63 (0.153)	RH 1.46 (<0.001)	-	RH, WS 1.65 (<0.001)
4 ^a	-	-	RH, WS 1.33 (<0.001)	RH 1.34 (0.046)	Rain 1.34 (<0.001)
5 ^a	-	RH 1.02 (0.419)	DL 1.14 (0.581)	BP, Rain, WS 1.04 (<0.001)	-

¹MT = maximum temperature; DL = day length; BP = barometric pressure; Rain = rainfall; RH = relative humidity; WS = wind speed.

^aPeriods with no data indicate that PC was significant for animal initial weight and/or initial age but not for an environmental variable.

Table 5. Coefficients of regression for the effects of selected weather variables on feed intake of individually-fed Angus bulls during feedlot performance tests.

Variable	Period on trial				
	1	2	3	4	5
	Parameter estimates				
Maximum temperature	-7.17	2.15	6.91	-17.52	-1.68
Day length	-5.03	6.26	6.07	-13.81	-0.91
Rainfall	0.66	3.45	-1.76	16.03	-8.05
Relative humidity	11.59	-6.50	-9.77	-4.80	-3.73
Barometric pressure	-12.38	-5.53	-4.27	-1.69	4.41
Wind speed	3.10	8.30	6.07	-0.71	-13.86

Table 6. Coefficients of regression for the effects selected weather variables on feed intake of individually-fed Polled Hereford bulls during feedlot performance tests.

Variable	Period on trial				
	1	2	3	4	5
	Parameter estimates				
Maximum temperature	-5.56	10.09	-4.25	4.04	-7.02
Day length	-6.22	10.28	7.82	-7.65	6.54
Rainfall	-0.53	-1.53	-11.85	-12.83	8.84
Relative humidity	7.95	-4.85	-7.64	150.28	-9.32
Barometric pressure	3.99	11.32	13.87	21.87	11.17
Wind speed	-4.86	-2.85	1.08	12.78	6.45

Table 7. Coefficients of regression for the effects of selected weather variables on feed intake of individually-fed Simmental bulls during feedlot performance tests.

Variable	Period on trial				
	1	2	3	4	5
	Parameter estimates				
Maximum temperature	15.03	-21.90	-12.55	20.95	4.67
Day length	20.68	52.32	35.64	1.39	-0.90
Rainfall	-8.07	3.45	-8.53	-5.39	-0.54
Relative humidity	28.09	2.85	13.62	-4.31	-12.18
Barometric pressure	1.45	19.78	32.77	29.02	9.17
Wind speed	27.00	9.95	21.85	4.95	-14.90