Diurnal Variation in Weight and Rates of Shrink of Range Cows and Calves

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Abstract

Cow-calf pairs were weighed on successive mornings to determine the effects of time on total weight. Early morning weights of mature Hereford/Angus crossbred cows were approximately 2.5% less than late morning weights in both the spring and summer. Weights of suckling calves were not significantly different between early and late morning. Linear regression analyses indicated drylot shrink weights of cows were primarily a function of length of time of shrink. Rate of weight loss was approximately 1% every 3 hours after an initial 3 hour loss of 3.5%. Secondary factors were status of cow (dry or wet), relative humidity (%), season (spring or summer) and initial cow weight. Shrink rates were slightly greater for wet cows than dry cows; when relative humidity was low; during spring; and for lighter weight cows. Rates of shrink of calves were primarily related to size of calf with calves weighing less than 53 kg (117 lb) gaining weight and calves weighing more than 53 kg losing weight.

Differences in liveweight of livestock are often used to evaluate the effect of various experimental treatments on livestock performance. At the Texas Experimental Ranch the magnitude of weight change over time of individual cows and the weaning weight of their calves are the principal parameters utilized to contrast the effects of stocking rate, grazing system and level of winter supplement (Heitschmidt et al. 1982). Because of the number of cattle in each treatment herd, gathering and weighing generally begins in early morning and extends into the early afternoon over a period of 3 days. Thus, weight differences between herds may reflect not only treatment effects but also the effects of the time of day the animals were gathered and weighed.

The first objective of this study was to quantify differences in cow and calf weights as a function of time of day when weighed. The second objective was to examine the rate of drylot shrink of both cows and calves as a function of length of shrink, environmental conditions, initial weight and time of day when the animals were gathered and penned. This objective was established to evaluate the feasibility of gathering herds and weighing after a predetermined period of shrink so as to standardize weights.

Methods

The study was conducted during the spring and summer of 1979 at the Texas Experimental Ranch located (99° 14′W, 33° 20′N) in Throckmorton County in the Northern Rolling Plains. Two of the 3 herds in a 4-pasture deferred rotation system (Merrill 1954) were selected for study. Each herd consisted of 24 Hereford/Angus crossbred cows of similar size and age. Ten of the 48 cows did not calve or had lost their calf prior to the study being initiated. Average date of calving for the 38 calves was mid-December. Both herds were located in pastures approximately 1.0 km from the weighing facilities.

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Experiment 1 was designed to examine the differences in cow and calf weights as a function of time of morning when the animals were gathered and weighed (Table 1). Experiment 2 was designed to quantify the rate of weight loss during the drylot shrink (Table 2). Both experiments consisted of replicated spring and summer trials run 1 week apart. Weighing of an entire herd generally required approximately 30 minutes. Although time to gather a herd within a pasture varied depending upon herd location, gathering and trailing time averaged approximately 1 hour. Ambient temperature (° C) and relative humidity (%) were recorded at time of each weighing event. All weights were recorded to the nearest 2.25 kg (5.0 lb).

Standard analysis of variance procedures were used to analyze the data from Experiment 1. The replicated 2×3 factorial designed model considered time of day, season of year, and herds as factors (Snedecor and Cochran 1967). Data from Experiment 2 were analyzed utilizing least squares stepwise linear regression procedures (Draper and Smith 1966). A series of analyses were run with percentage shrink as the dependent variable. Independent quantitative variables included individual pre-shrunk weights and time weighted averages for temperature (° C and ° F), relative humidity (%), and a temperature/relative humidity ratio (° C/%RH and ° F/%RH). Dummy variables of 1 and 0 were used for status of cow (wet or dry), season of trial (spring or summer), and initial time of day that the trial shrink was begun (a.m. or p.m.). Age of calf (days) was also included as an independent variable in the calf weight analyses. The regression procedures added independent variables if they met the $P = 0.50$ level of significance for the partial F-value. All variables included in the models and discussed in this paper were highly significant ($P<0.01$) as were the R^2 values.

Results and Discussion

Time of Weighing

The analysis of variance indicated that lactating cows with calves (wet cows) gain a significant ($P<0.01$) amount of weight during mornings. Early morning weights averaged 457 kg while late morning weights averaged 468 kg. The analyses also indicated that cows in herd A were significantly ($P<0.05$) lighter (459 kg) than cows in herd B (466 kg) and that the cows weighed significantly ($P<0.01$) more in the summer (476 kg) than in the spring (449 kg). All first order interactions were nonsignificant ($P<0.05$).

The significant weight increase during the morning was assumed to be the result of increased rumen fill in conjunction with grazing. Taylor (1954) reported that the weight of the contents of the alimentary tract of mature cattle range from 12% to 22% of the total liveweight. Thus, differences in level of fill can dramatically affect liveweights. Under range conditions, Hughes and Harker (1950) reported that 600 kg steers gained weight while grazing at a rate of 11.4 kg/hour and lost weight while resting at an average rate near 2.0 kg/hour. Thus under range conditions, grazing behavior is the major factor altering level of rumen fill at any give time. The reported effects that such factors as quantity and quality of available forage (Hughes 1976), type of grazing system (Taylor 1954), and availability of water (Whiteman et al. 1954) have on level of rumen fill are directly related to the effect these factors have on

Table 1. Calendar date, herd, time of weighing (CST), temperature (°C), and relative humidity (%) at time of weighing and average weights (kg) for Experiment 1.

Date	Herd	Time	°C	% RH	Weight		
					Wet cows	Calves	Dry cows
May 8	B	7:00	20	96	440	150	475
	A	10:45	27	58	447	144	458
May 9	A	7:45	21	80	432	143	447
	B	10:15	24	64	451	151	480
May 15	A	6:15	12	90	445	151	462
	B	10:15	24	34	464	161	492
May 16	B	6:15	11	100	456	162	492
	A	10:00	22	40	456	153	470
July 23	A	7:30	23	98	466	215	503
	B	10:30	35	30	484	230	532
July 24	B	7:30	23	85	478	228	527
	A	10:30	30	45	479	217	508
July 30	B	7:30	26	72	476	233	532
	A	10:30	32	72	484	226	515
July 31	A	7:30	22	100	461	223	501
	B	10:30	23	85	477	232	527

grazing behavior (Hughes and Harker 1950).

Results from the last trial of the study (July 30 and 31) emphasized the effect that environmental factors can have on the weight of a grazing animal if grazing behavior is altered such that level of fill is affected. July 30 was a clear, warm summer day and cow weights were very similar to those for the same time of day on July 23 and 24 (Table 1). But the weights on July 31 were well below those expected presumably because rumen fills were less than expected. Apparently the cows did not graze during the morning of July 31, a change in grazing behavior which presumably was related to the rain (Table 1). Excluding the weights from the last trial, percentage differences in wet cow weights between early and late morning ranged from a maximum of 3.4% for herd A on May 8 and 9 to a minimum of 1.3% for herd B on July 23 and 24. The average gain during mornings for all the trials was 2.5%

Although the weight gain of dry cows from early to late morning was statistically nonsignificant, trends were similar to those established for wet cows although of reduced magnitude. Averaged across all trials, weights increased during mornings 1.1% ranging from an increase of 2.8% in herd A during the last trial to a decline of -0.9% in herd B on the same date. These extremes during the last trial were likely related to the weather conditions as discussed earlier. Excluding these data, morning weight gains ranged from zero to 2.4% with an average gain of 1.0%. The reduced magnitude of morning weight flux of the dry cows in contrast to the wet cows was presumed to be related to two factors; rumen fill and milk secretion. Allen (1946) reported that weights of lactating animals fluctuate more within a day than nonlactating animals because of the relatively greater quantities of food and water that are consumed by lactating animals, as well as the loss of weight resulting from milk secretion.

Analyses of the calf weights indicated no significant ($P<0.05$) differences between early and late morning weights or between herds although calves were significantly ($P<0.01$) heavier in the summer than the spring. All first order interactions were nonsignificant ($P<0.05$). The absence of a significant treatment by season interaction indicated that treatment effects did not become significantly more pronounced as the calves grew during the spring and summer. However, gains during the morning averaged 0.6% in May, ranging from -0.6% to 1.7%, while in July gains averaged 0.9% ranging from -0.2% to 1.5%. Although statistically nonsignificant, this 0.3% average increase indicated that as the calves grew, diurnal variation in liveweights was becoming more pronounced. This would be expected since Kirton and Paterson (1971) reported that the weight of the stomach contents of 3-day-old calves was only 4% of total liveweight as opposed to the 12% to 22% reported by Taylor (1954) for mature cattle.

From these analyses it was concluded that range cows generally gain weight from early to late morning if permitted to graze but the effect that the time of day has on the weight of suckling calves is minimal.

Rate of Shrink

The stepwise linear regression selected time in drylot (x_1) as the best single variable for predicting the percent shrink of the cows (Table 3). The +0.35 coefficient indicated rate of shrink averaged approximately 1% every 3 hours after an initial 3-hour shrink of approximately 3.5%.

When percent shrink was plotted against hours in drylot, an obvious curvilinear relationship was apparent (Fig. 1). When the data were fit by least square regression procedures to the allometric function of $y = ax^b$, the R^b value increased to 0.69. This increase in the R^2 value was attributed primarily to a better fit of the data when shrinks were less than 7 hours. For example, at 3 hours predicted shrink from the equation $y = 2.43 + 0.35X_1$ was 3.48% as compared to a predicted value of 2.53% from the allometric function of $y = 0.16X_1^{0.70}$. The herd means for percent shrink from the field

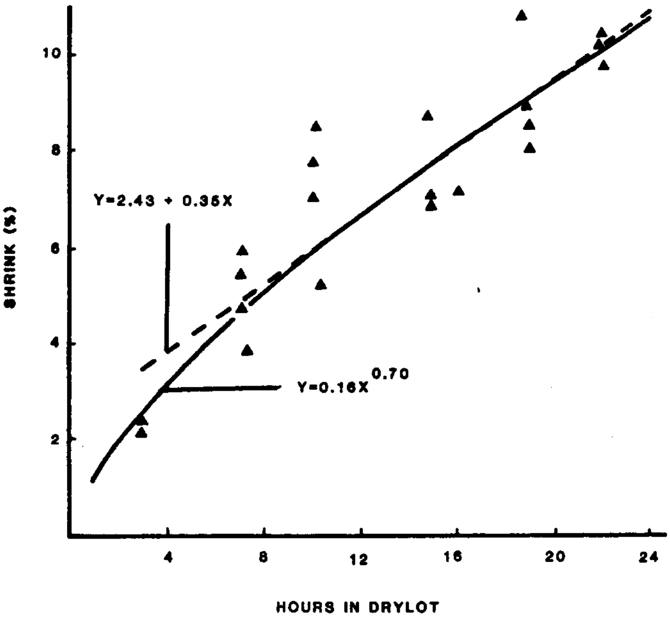

Fig. 1. *Percent loss of weight (Y) of range cows as a function of hours in drylot (X) at the Texas Experimental Ranch.*

Table 2. Calendar date, herd, time of weighing (CST), temperature (°C) and relative humidity (%) at time of weighing and average weights (kg) for Experiment 2.

Date	Herd	Time	°C	% RH	Weights		
					Wet cows	Calves	Dry cows
April 25	A	7:00 am	18	82	425	130	443
		2:00 pm	31	20	399	126	421
		5:15 pm	24	32	388	125	415
April 25	B	4:40 pm	18	82	440	137	481
April 26		7:25 am	10	64	399	135	449
		11:20 am	18	42	388	133	441
May 3	B	6:45 am	16	96	434	145	473
		1:55 pm	12	100	416	141	459
		4:45 pm	11	100	409	141	455
May 3	A	3:45 pm	11	100	441	140	458
May 4		7:45 am	7	90	409	138	428
		10:30 am	11	70	401	137	422
		2:00 pm	11	58	395	136	417
July 9		6:00 am	21	90	466	203	502
		9:00 am	32	40	455	200	494
		1:00 am	37	26	440	196	479
		4:00 pm	37	26	430	193	468
July 9	B	3:30 pm	37	26	487	217	527
July 10		6:30 am	20	96	451	210	502
		10:30 am	28	50	443	206	492
		1:30 pm	22	78	434	204	486
July 16	B	6:00 am	24	74	469	220	521
		9:00 am	29	58	457	216	511
		2:00 pm	35	28	445	213	502
		4:00 pm	37	25	434	210	492
July 16	A	3:30 pm	37	25	477	211	510
July 17		6:30 am	22	100	442	203	485
		10:30 am	22	100	437	202	479
		1:30 pm	24	72	430	200	470

data after 3 hours were 2.2% and 2.4% (Fig. 1). However, for the period from 7 to 22 hours both the linear and the allometric equations predicted percent shrink equally well. For 10 and 20 hours in drylot, predicted shrinks were 5.93% and 9.43% from the linear equation and 5.88% and 9.55% from the allometric equation. Thus, it was concluded that the linear regression adequately describe the relationship between percent shrink of the cows and time in drylot for periods of shrink between 3 and 22 hours although the allometric function described the relationship slightly better. This was a desirable conclusion since the use of linear regression procedures simplified the biological interpretation of the data. Furthermore, the level of mathematics necessary to apply the least square equations to actual field situations is considerably less when relationships are described as linear functions rather than allometric.

The rates of shrink for the cows in this study agreed rather closely with previous studies. Taylor (1954) reported drylot shrinks averaging 5.6% for 12 hours and 8.2% for 24 hours for mature steers that initially weighed 535 kg. This is in comparison to predicted shrinks for the cows in this study of 6.6% for 12 hours and 10.8% for 24 hours. In a series of trials Whiteman et al. (1954)

Table 3. Stepwise linear regression coefficients selected to predict weight loss of drylotted range cows at the Texas Experimental Ranch where y = shrink (%); X_1 = time in drylot (hours); X_2 = status of cow (0 = dry, 1 = wet); X_3 = relative humidity (%); X_4 = season of year (0 = spring, 1 = summer); and X_5 = initial weight of cow (kg). All associated R^2 values were significant at $P<0.01$ (d.f. = 503).

Regression coefficients	R^2
$y = 2.45 + 0.35X_1$	0.60
$y = 0.98 + 0.34X_1 + 1.85X_2$	0.67
$y = 3.04 + 0.38X_1 + 1.82X_2 - 0.04X^3$	0.72
$y = 5.86 + 0.39X_1 + 1.80X_2 - 0.06X_3 - 1.79X_4$	0.79
$y = 9.11 + 0.40X_1 + 1.53X_2 - 0.06X_3 - 1.45X_4 - 0.01X_5$	0.80

reported overnight shrink rates ranging from 2.3% to 6.1% for growing steers that initially weighed about 415 kg. Differences in rate of shrink were related to preshrunk differences in level and type of fill. Hughes (1976) in a summarization of the findings of Whiteman et al. (1954) and other similar types of research conducted at the Grassland Research Station (1953), reported 12-hour shrinks ranging from approximately 18 kg to 40 kg for steers ranging in weight from 464 to 577 kg. Twenty-four hour shrinks ranged from 34 to 62 kg. Assuming an average pre-shrunk weight of 520 kg, the average 12-hour shrink was 5.6% and the average for 24 hours was 9.2%. Likewise, Wythes et al. (1980) reported 12- and 24-hour shrinks of 5.9% and 7.4% for steers weighing an average of 296 kg.

The second variable selected in the analyses was status (dry or wet) of cow (X_2). The +1.85 coefficient (Table 3) indicated that wet cows lost 1.85% more weight than dry cows, regardless of time of shrink. Predicted shrinks for dry cows at 12 and 24 hours were 5.2% and 9.4%. Adding the 1.85%, predicted shrinks for the wet cows were 7.0% and 11.2% for 12 and 24 hours, respectively. The increased rate of shrink for the wet cows was most likely because their preshrink level of fill was greater than that of the dry cows and they sustained a greater loss of weight because of the secretion of milk (Allen 1946).

The third variable selected was relative humidity (X_3) (Table 3). The -0.04 coefficient indicated that rate of shrink was reduced slightly as relative humidity increased. A biological explanation as to why shrink rates were reduced in conjunction with an increase in relative humidity is at best speculative since the selection of relative humidity over temperature was not expected. Paine et al. (1977) reported that increasing temperature reduced average daily gains of cattle in feedlots more than initial weight, wind speed, precipitation or relative humidity. Furthermore, it has been shown that rate of respiration of beef cattle is closely correlated with body temperature (Paine and Butchbaker 1971). Since cattle rely on respiration as the primary method of heat release (Paine 1976), one would expect weight losses to be more closely related to temperature than relative humidity. However, because of the close relationship between relative humidity and temperature during the trials ($r = -0.85$, $P<0.01$), temperature apparently became relatively unimportant once relative humidity entered the equations.

The fourth variable selected was season of year (X_4) that the trial was run (Table 3). The -1.79 coefficient indicated that rate of shrink was less during summer than spring. However, because of differences in environmental conditions between spring and summer this coefficient only slightly modified the predicted shrink.

The final variable selected was the initial preshrunk weight of the cow (X_5). Although the -0.01 coefficient (Table 3) indicated that rate of shrink decreased slightly as initial weight increased, it is doubtful that this phenomenon was related to level of rumen fill. If it were assumed that the heavier weight cows were heavier because of greater levels of fill, then these results would be in conflict with previous findings which have shown that the greater the preshrink fill the faster the shrink (Hughes 1976). Rather, it was assumed that the -0.01 coefficient was most likely describing the interaction effect of several interdependent factors. For example, it was assumed that it reflected at least in part the slightly accelerated shrink rate that had already been established for the lighter weight wet cows as compared to the heavier weight dry cows. Also, since relative humidities were lower and temperatures were higher during the daytime shrinks than the nighttime shrinks (Table 2), shrink rates during the day would be expected to be slightly greater than those during the night. Again this would suggest that lighter cows shrink faster since the initial preshrink weights for the cows when gathered in early morning averaged approximately 13 kg less than when the cows were gathered in the afternoon for the overnight shrink.

Three independent variables did not satisfy the $P=0.50$ significance level required for inclusion. These variables were ambient air temperature, the relative humidity/temperature index and the time of day that the trial was begun. In each instance the lack of total independence from other factors already included in the model most likely diminished the significance of any of these factors.

From these analyses it was apparent that rate of shrink of the cows was primarily a function of time in drylot. This was evidenced by both the selection of time as the first independent variable and the relatively small increases in the R^2 value that occurred with the addition of each new variable.

Rate of shrink (y) of the suckling calves was primarily a function of three variables: initial weight of calf (X_1); time in drylot (X_2); and time of day (X_3) trial was begun (Table 4). The -1.60 intercept coefficient, in conjunction with the +0.03 coefficient for the preshrink weight (X_1), suggested that no shrink was predicted until calves weighed approximately 53 kg. The +0.03 coefficient suggested rate of shrink would increase slightly as initial weight of calf increased. Presumably, this slight acceleration was related to the relative increase that gut fill may have on total liveweight as an animal grows. Also, drylotting young calves does not deprive the calves of their primary food source since they probably continue to receive a near normal portion of milk.

Time in drylot (X_2) was selected as the second best variable for predicting shrink of calves (Table 4). The +0.10 coefficient suggested a slightly greater shrink occurred as time in drylot was extended. The final variable selected was time of day when the shrink was begun (X_3). The -2.45 indicated rates of shrink declined during nights in contrast to daytime shrinks. This was most likely related to the lower temperatures and higher relative humidities experienced during nights relative to days. No other variables met the $P = 0.50$ level of significance for inclusion in the model.

Table 4. Stepwise linear regression coefficients selected to predict weight loss of drylotted suckling calves at the Texas Experimental Ranch where y = shrink (%); X_1= initial weight of calf (kg); X_2 = time in drylot (hours); and X_3 = time of day trial was begun (0 = morning, 1 = afternoon). All associated R^2 values were significant at $P<0.01$ (d.f. = 400).

Regression coefficients	R^2
$y = -1.60 + 0.03\ X_1$	0.28
$y = -3.05 + 0.03\ X_1 + 0.10\ X_2$	0.35
$y = -4.14 + 0.03\ X_1 + 0.26\ X_2 - 2.45\ X_3$	0.41

It was concluded from these analyses that rate of shrink of the suckling calves was minimal if the calves were left with their mother cow. This was particularly true for smaller calves. For example, after 10 hours predicted shrink for a 100 kg calf was only 0.5%. However, as the calves reached weaning weight rates of shrink began to reflect rates similar to those of more mature cattle. For example, after 10 hours predicted shrink for a 300 kg calf was 5.7%. This compares to a predicted shrink of 5.9% for a mature wet cow.

Conclusions

These data suggest that if at all possible, cow weights obtained to contrast grazing treatment effects should be collected at a similar time of day under similar environmental conditions. These data also suggest that a period of drylot shrink prior to weighing will not standardize range cow weights unless length of shrink and environmental conditions during the shrink are similar. It is assumed, in contrast to the findings of Whiteman et al. (1954), that trailing increases rates of shrink. Thus, it is recommended that under range conditions, those cows nearest the weighing facilities be weighed first and those farthest from the facilities be weighed last.

These data indicate that the magnitude of both the diurnal weight fluctuation and the rate of drylot shrink of suckling calves is a function of size of calf in that the lighter the calf the less diurnal weight fluctuation and rate of drylot shrink. But since calves at weaning often weigh 300 kg, every precaution should be taken to obtain accurate weights especially since 10 kg differences in calf weaning weights is sufficient economic justifications for advocating certain grazing management practices. Thus, it is concluded that the same order of weighing utilized to weigh the cow herds should be followed when weighing the calves.

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