Behavior of Range Cows in Response to Winter Weather

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Highlight: *Hereford cows consuming a sub-maintenance diet on a northern Utah winter range altered their daily behavioral routines in response to changes in weather. They spent more time grazing and less time standing on warm days than on cold days. They also grazed and ruminated for longer time periods following changes in atmospheric pressure. Distances the cows traveled daily were highly and inversely related to average daily wind velocities. The net result of these alterations in behavioral patterns was a reduction in energy expenditures for physical activities during periods of weather stress.*

Winter maintenance of the dry cow represents one of the largest investments of food energy in the western cow-calf production system. Low-cost range forage has traditionally been utilized whenever possible to minimize the expense of this investment. However, cattle wintering on open rangelands, as opposed to those wintered in semiconfined feeding situations, are confronted with environmental stresses that may contribute to increased maintenance energy costs. For example, range cattle must expend energy in the search for and harvest of food (Osuji, 1974), and, in cool temperate zones, they are subject to periods of energy-draining climatic stress. Despite the probable economic importance of the question, knowledge of the physiological and behavioral processes of acclimatization to cold by large domestic animals is generally incomplete (Webster, 1974).

On the premise that there exist unknown adaptive mechanisms in livestock behavior that have potential for application in management programs, we undertook the following study. Our working hypothesis was that range cows modify their behavior in response to weather, and the direction and magnitude of these modifications result in a conservation of body energy.

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Methods and Materials

Area

The study was located in Curlew Valley in extreme northern Utah. The area is typical of much of the low elevation (1,250–1,850 m) cold desert ranges in the Great Basin. Intermittent periods with temperatures of -20°C and colder are common during the winter, and low temperatures are often accompanied by winds of 8 to 35 km/hour during storms of generally less than 24-hours duration. Snow accumulations are generally less than 30 cm in depth.

Study Site and Animals

A fenced area of approximately 2,000 ha, known as the Curlew Valley Validation Site of the US/IBP Desert Biome Project, served as the study site. Approximately half of the area had been revegetated with crested wheatgrass (*Agropyron cristatum*) in 1965. The remainder of the area supported native salt desert shrub vegetation, including such species as big sagebrush (*Artemisia tridentata*), shadscale (*Atriplex confertifolia*), and rabbitbrush (*Chrysothamnus viscidiflorus*). The area was grazed by 500 mature, pregnant Hereford cows from mid-November to mid-January during the two winters of 1971–72 and 1972–73 when the study was conducted. Little natural and no artificial shelter was available to the cows. The area was generally level, with the only relief being afforded by a shallow (0.8 to 2 m) depression. Water was located only at one end of the rectangularly shaped pasture. The cattle received no supplemental feed during the study period.

Study Methods

This paper presents results obtained during 24-hour observations of the cow herd in the 1972–73 grazing season; however, the herd was also observed during the daytime in the 1971–72 grazing season. The sampling scheme consisted of continuous 24-hour observation of an individual cow that had been selected randomly from the herd on each of the 15 observation days. Observations were conducted every fourth day during the 2-month grazing season and were generally from the cab of a pickup truck which could be driven within 30 meters of the animals without disturbing them. Nighttime observations were aided by a spotlight. A continuous log of activities was developed for the purpose of establishing daily and diurnal behavioral routines. For purposes of this paper, the following behavioral variables were quantified on a 24-hour basis: (a) time spent grazing, (b) time spent ruminating, (c) time spent standing, (d) time spent lying, and (e) distance traveled (measured from plots on aerial photographs). Additionally, daily weather conditions were monitored on the site with respect to the following variables: (a) mean wind speed (from bi-hourly recordings), (b) mean air temperature (from bi-hourly recordings), (c) barometric pressure (continuously recorded), and (d) net solar radiation (continuously recorded).

Alterations in daily behavioral patterns were related to changing weather conditions by simple linear correlation and regression procedures (Snedecor and Cochran, 1967). Additionally, an activity budget was developed that represented the average daily expenditure of net energy for the four maintenance-related activities mentioned above (lying was not considered an energy-demanding activity). Energetic costs of these activities were calculated from published values. The recent review by Osuji (1974) of energy expenditures of the ruminant at pasture was used in selecting appropriate values for these calculations. Variations in the daily expenditure of energy for activities were related to weather conditions by multiple regression techniques (Snedecor and Cochran, 1967).

Results and Discussion

Mean daily air temperature during the days when cows were observed varied from a high of 5°C to a low of -24°C. Daily wind speed ranged from a low of 0.4 km/hour to a high of 15.5 km/hour on one day. Net solar radiation varied from 32 to 216 Langleys per day, and the greatest absolute change in barometric pressure during a 24-hour period was 10.2 mm Hg. Within this range of climatic conditions, several statistically significant correlations were noted between weather events and animal behavioral patterns. These are summarized in Table 1, and simple linear regression equations for the significantly correlated variables are presented in Table 2.

Air Temperature

Mean daily air temperature was positively related to time spent grazing and inversely related to time spent standing (Tables 1 and 2). There were no other statistically significant ($P \leq 0.05$) relationships involving air temperature.

Table 2. Simple linear regression equations relating cattle activities (Y_n) to weather variables (X_n).

Variables	Regressions	$s_{y \cdot x}$
Daily air temp. (X_1) – grazing time (Y_1)	$\hat{Y}_1 = 16.58 + 0.10X_1$	0.77
Daily air temp. (X_1) – standing time (Y_2)	$\hat{Y}_2 = 1.31 - 0.06X_1$	0.46
Δ press. (X_2) – grazing time (Y_1)	$\hat{Y}_1 = 8.63 + 0.18X_2$	0.82
Δ press. (X_2) – ruminating time (Y_3)	$\hat{Y}_3 = 8.11 + 0.23X_2$	0.78
Daily wind velocity (X_3) – distance traveled (Y_4)	$\hat{Y}_4 = 9.60 + 0.88X_3$	0.99
Daily wind velocity (X_3) – ruminating time (Y_3)	$\hat{Y}_3 = 7.68 + 0.33X_3$	0.78

Barometric Pressure Change

Barometric pressure tended to decline 12 to 24 hours prior to the passage of winter storm fronts and then rise during or immediately after the storms. The entire cycle was generally less than 48 hours in duration.

Initial analysis of data indicated no significant correlations between contemporaneous readings of atmospheric pressure and behavioral variables. However, when we regressed behavioral variables upon the absolute magnitude of pressure change during the 24-hour period from 6:00 p.m. the evening preceeding an observation day to 6:00 p.m. during the observation day, significant relationships were discovered (Tables 1 and 2). Time spent grazing and ruminating increased in response to either rising or falling pressure changes, but the duration of these increases must have been short-lived (i.e., the response to an initial pressure change had decayed prior to onset of a subsequent pressure change-animal response), else, ever-increasing amounts of grazing and ruminating time would have been observed.

Considering the relatively low degree of correlation (Table 1), the complex nature of the relationships, and the lack of supportive information from the literature, these relationships should be viewed as tentative.

Table 1. Simple correlation coefficients relating cattle activities to weather variables.

	Daily cattle activities				
	Distance	Time spent			
Weather variables	traveled	grazing	ruminating	standing	lying
Mean daily air temperature	0.20	0.65**	0.22	−0.63*	−0.46
Δ barometric pressure	−0.37	0.56*	0.68*	−0.49	0.05
Mean daily wind velocity	−0.90**	0.28	0.70*	−0.10	0.47
Net solar radiation	−0.27	−0.11	0.29	−0.01	0.47

*$P \leq 0.05$.
**$P \leq 0.01$.

Wind velocity

Mean daily wind velocity was highly but inversely correlated to daily distance traveled (Table 1). This relationship was due in part to animals' refusal to travel to water on windy days. Daytime observations on two extremely windy days during the 1971-72 grazing season suggested that this inverse relationship holds only up to a point. At some undetermined threshold, wind velocity greater than the 15.5 km/hour which was the peak daily average observed during 1972-73, it is likely that traveling distance increases with increasing wind velocity. It is a common observation that cattle "drift" with high winds (Hafez, 1968).

Our data offer no apparent basis for explaining the positive correlation between average daily wind velocity and time spent ruminating.

Net Solar Radiation

Correlations between net solar radiation and animal activities monitored were not statistically significant ($P \leq 0.05$), but there appeared to be a threshold level of light necessary for the onset of grazing activity in the morning (Smith, 1973).

The majority of the significant correlations presented in Table 1 are not particularly "strong" in the statistical sense. However, they would not be expected to be so. Each animal species has an innately established repertoire of activities related to its fundamental anatomy and life processes, and the pattern (duration, frequency, amplitude, etc.) of these activities is generally quite stable, even under unusual conditions frequently imposed by domestication (Scott, 1969). Weather is only one of the many extrinsic factors that serve to modify this pattern. Thus, while an occasional close association may be found for some weather event and a particular activity (within a rather specific range of each)

Table 3. Unit net energy costs used in calculation of energy requirement for activity.

Activity	Unit cost (net energy)	Reference source
Grazing	0.77 kcal/hour/kg[a]	Mean of nine values from Osuji's (1974) Table 2. Data from six independent sources.
Standing idle	0.15 kcal/hour/kg	Mean of Osuji's (1974) Table 1. Data from 10 sources.
Ruminating	0.24 kcal/hour/kg	Graham (1964)
Traveling	0.45 kcal/km/kg	Brody (1945)

[a]Includes cost of harvesting, masticating and swallowing forage (0.62 kcal/hour/kg) as well as the cost of standing associated with grazing (0.15 kcal/hour/kg) but not the cost of locomotion associated with grazing.

Table 4. Calculated net energy costs of daily activities to cows grazing winter range.

Activity	Mean daily[1] quantity and standard deviation	Energy expenditure (kcal)	Percentage of total activity cost
Grazing	9.5 ± 0.6 hour	2,525	59
Standing	1.7 ± 0.9 hour	88	2
Ruminating	8.9 ± 1.0 hour	725	17
Traveling	6.3 ± 2.1 km	965	22
Lying	12.2 ± 0.9 hour	–[2]	–[2]

[1]Total hours of daily activities do not equal 24 because traveling was more accurately quantified on the basis of distance traversed than on the basis of time duration, and rumination occurred while animals were standing as well as while they were lying.
[2]Lying was not considered as an energy-demanding activity.

this would not generally be the case for all activities and components of weather. Simple correlation and regression analyses can best be used in a relative way for identifying these important relationships.

Energy Costs for Activities

Assuming that energy expenditures per unit (time duration or distance) of individual activity are additive, the average daily energy budget for activities associated with maintenance was calculated using the values specified in Table 3. This daily energy budget is presented in Table 4. Clearly, grazing represented the major expenditure by virtue of its relatively high unit-cost and, especially, the high investment of time in that activity.

The day-to-day variation in total energetic costs for activities over which the animal can exert voluntary control (i.e., grazing, traveling, and standing or lying) should reflect the animal's integrated response to important environmental stimuli if cows do, indeed, modify their behavior to minimize energy loss. A step-wise multiple regression analysis of daily energy expenditures, using the three significant weather variables from Table 1 as the independent variables, showed average daily temperature to be most important in this respect (Fig. 1). Inclusion of the variables daily wind speed and daily barometric pressure change into the regression model accounted for only an additional 3% of the variation ($r^2 = 0.85$) in energy expenditures for activities.

The three "outliers" (Snedecor and Cochran, 1967) seen in Figure 1 were not included in either the multiple or simple regression analysis. The two designated by the letter "S" (Fig. 1) resulted from observations made on days when measurable quantitites of snow fell during the 24-hour observation period. The other, designated by the letter "T" (Fig. 1), resulted from a 24-hour observation period when the average temperature (-23.7°C) was appreciably lower than that for all other observation periods. The data suggest that the relationship between energy expenditure for activities and air temperature (Fig. 1) is valid only within a specific range of ambient temperatures that lies near or above the animal's minimum critical temperature (roughly -14°C as calculated by Young's (1971) nomogram), and under conditions such that a dry hair coat is assured.

Hafez (1968) has stated that ungulates in general adapt their behavior to their need for warmth. A commonly observed adaptation is the assumption of particular body postures by animals faced with cold. In this connection, cows in our study tended to orient the major axis of their bodies at right angles to the sun during periods of sunshine on cold days.

Other important behavioral adaptations to cold relate to ingestive behavior and locomotor activity. Appetite drive increases in all homeothermic species during long-term exposure to cold (Cabanac, 1974). Webster et al. (1970) reported that food intake by cattle in a cold environment appeared to be a function of how cold it was at the time. Hafez (1968) has suggested increased heat

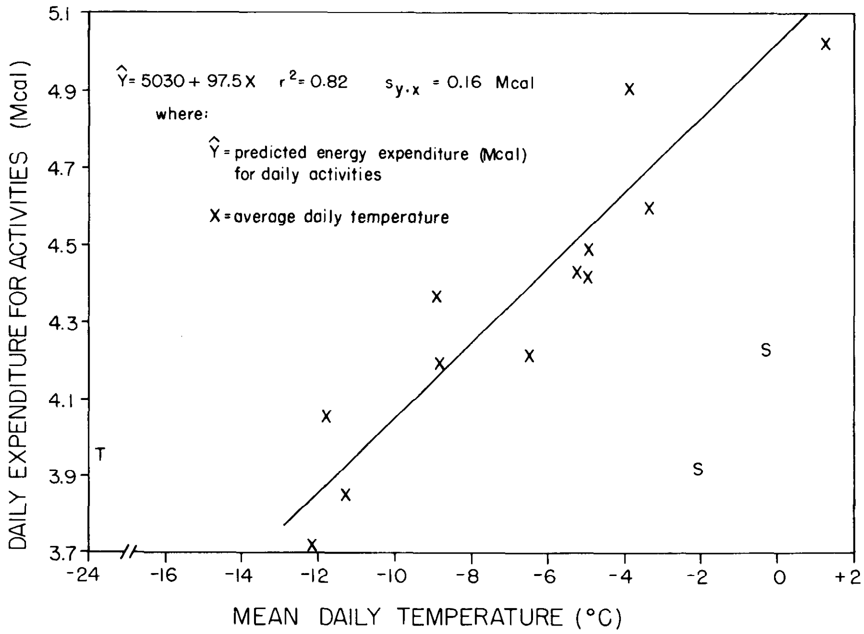

Fig. 1. *Relationship between energy expenditure for daily activities by range cattle and mean daily temperature.*

production through locomotor activity as a possible mammalian tactic for combating cold, but has offered no supportive data for large ungulates.

The foregoing findings appear initially to be contrary to data reported in Tables 1 and 2 and Figure 1 if one assumes that food intake by range cows is directly related to time spent grazing. Our cows grazed less on cold than on warm days; therefore, they likely consumed less forage on cold days. However, they expended less energy on cold days. The most probable distinction between our findings and those reported in the literature relates to the availability of food. Cows in the present study were unable to obtain their maintenance need from the range. The average 345-kg cow lost 136 grams of body weight daily during the course of the grazing period; whereas, the studies quoted above were conducted under conditions where food quantity was not as limited. When the ambient temperature approached our cows' critical temperature, they apparently deferred to a later, warmer period some of the energy expenditures necessary for grazing. Similar findings have been reported by Moen (1973) from work with white-tailed deer (*Odocoileus virginianus*) wintered under conditons of food scarcity. Moen concluded that the dynamic behavioral response of deer to cold seems to be one of heat conservation rather than the energetically more expensive heat-production response. Such a tactic has obvious survival advantages under conditions of intermittent cold and moderate temperatures, and is consistent with literature on the theory of feeding strategies (Schoener, 1971).

Results of this study suggest that wintertime management operations resulting in the disturbance of animals' normal behavioral routines (ex. intermittent provision of supplementary feed, moving animals, etc.) might best be conducted on warmer days when cattle are normally active. Further, our calculated net energy cost for activities of 4.3 mcal daily suggests that the recommendation of 10.3 mcal metabolizable energy for daily maintenance of dry, pregnant, mature 350 kg cows (Nat. Acad. Sci., 1970) considerably underestimates the maintenance energy requirements of range cattle, where forage is sparse.

Literature Cited

Brody, S. 1945. Bioenergetics and growth. Reinhold and Co., New York. 1,023 p.

Cabanac, M. 1974. Thermoregulatory behavior. p. 231-270. *In:* D. Robertshaw, ed., Environmental Physiology. University Park Press, Baltimore, Md.

Graham, N. McC. 1964. Energy costs of feeding activities and energy expenditure of grazing sheep. Aust. J. Agr. Res. 15:969-973.

Hafez, E. S. E. 1968. Behavioral adaptation. p. 202-214. *In:* E. S. E. Hafez, ed., Adaptation of Domestic Animals. Lea and Febiger, Baltimore, Md.

Moen, A. N. 1973. Wildlife Ecology. W. H. Freeman Co., San Francisco. 458 p.

National Academy of Science. 1970. Nutrient requirements of domestic animals, No. 4. Nutrient requirements of beef cattle (4th revised ed.) Nat. Acad. Sci., Washington, D.C.

Osuji, P. O. 1974. The physiology of eating and the energy expenditure of the ruminant at pasture. J. Range Manage. 27:437-443.

Schoener, T. W. 1971. Theory of feeding strategies. p. 369-404. *In:* R. F. Johnston. ed., Annual Review of Ecology and Systematics. Annual Reviews, Inc., Palo Alto, Calif.

Scott, J. P. 1969. Introduction to animal behavior. p. 3-21. *In:* E. S. E. Hafez, ed., The Behavior of Domestic Animals. Williams and Wilkins Co., Baltimore, Md.

Smith, B. M. 1973. The relationship of climatic factors to grazing activities of cows on winter and spring ranges. MS Thesis. Utah State Univ., Logan. 88 p.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical Methods (6th ed.) Iowa State Univ. Press, Ames. 593 p.

Webster, A. J. F. 1974. Adaptation to cold. p. 71-106. *In:* D. Robertshaw, ed., Environmental Physiology. University Park Press, Baltimore, Md.

Webster, A. J. F., J. Chlumecky, and B. A. Young. 1970. Effects of cold environments on the energy exchanges of young beef cattle, Can. J. Anim. Sci. 50:89-100.

Young, B. A. 1971. A practical means for estimating cold stress in cattle. Proc. 50th Annual Feeders Day. Dep. Animal Sci., Univ. Alberta, Edmonton. p. 12.