# Relationship of Distance Traveled with Diet and Weather for Hereford Heifers

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## Abstract

**Distance traveled by Hereford heifers under continuous and high-intensity low-frequency (HILF) grazing was highly correlated with crude protein, digestible energy, forb content, and the ratio of grass leaf blade to stem plus leaf sheath obtained from diets collected via esophageal fistula. Observations confirmed that availability of palatable forbs was positively correlated with animal travel under HILF grazing management. Animal travel decreased under both management systems between July and December. Maximum diurnal temperatures and maximum diurnal water vapor, expressed as maximum mixing ratio, were significantly associated with travel under HILF grazing. Calculations indicated that the energy cost associated with horizontal travel for range cattle is greater than that allowed in the basal metabolism requirement set forth by the National Research Council.**


Grazing and walking locomotion occupies more than 50% of a cow's day, i.e., between the time of rising in the morning to the time of bedding in the evening (Cory 1927; Dwyer 1961). The energy cost for this movement varies, depending upon slope. Brody (1945) placed the cost of 0.45 kcal/kg-km for the horizontal locomotion of cattle. Ribeiro et al. (1977) reported that *Bos taurus* cattle weighing between 383 and 930 kg required 0.48 kcal/kg-km for horizontal locomotion and 6.21 kcal/kg-km if travel occurred up a 6° incline. According to Clapperton (1961) and Christopherson and Young (1972), walking up a gradient is about 10 times as demanding as walking on a horizontal plane. Cook (1970) reported that the energy cost to walk down a slope was the same as the energy cost to walk on the level.

Movement is an innate characteristic of the animal world. Schake and Riggs (1972) found that for Hereford cow-calf pairs maintained in confinement the cows averaged traveling 0.61 km/da and the calves 0.14 km/da. Osuji (1974) pointed out that in areas where animals have to travel long distances for adequate food and water the energy cost of walking could be high. For 3 years, Herbel and Nelson (1966) recorded travel of Santa Gertrudis and Hereford cows grazing semidesert pastures 1,000 to 1,500 ha in size and found travel ranged between 6.9 and 14.6 km/da. Durham (1975) observed Santa Gertrudis cows on a 900-ha Gulf Coast Prairie pasture near Victoria, Texas, and found travel distances between 4.2 and 7.4 km/da for a 4-month period beginning in December. Travel of Hereford cows grazing on approximately 2,000 ha of Utah's Great Basin between mid-November and mid-January averaged 5.8 km/da; however, when wind speeds exceeded 3.2 kmph, travel decreased to 2.4 km/da (Malechek and Smith 1974).

Distance livestock travel is influenced by many factors including temperature (Malechek and Smith 1976), wind (Dwyer 1961; Ruckebush and Bueno 1978), stage of gestation (Squires 1974), and nutritional level (Schake and Riggs 1972). Previous studies (Cory 1972; Shaw et al. 1977) show that daylength (hours between sunrise and sunset) may contribute to seasonal animal travel. However, diurnal light as influenced by phase of the moon does not appear to affect animal travel (Dwyer 1961).

The object of this study was to determine the degree of association between heifer travel under continuous and high-intensity low-frequency (HILF) grazing to both diet and weather factors.

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## Materials and Methods

These data were obtained from a non-replicated grazing study conducted during 1975 on the Texas Experimental Ranch in

Throckmorton County, Texas. Five 4-ha paddocks were grazed in a HILF grazing system consisting of five paddocks grazed by one herd for 28 days followed by 112 days of rest [5-1;28:112 da][1]; and one 20-ha paddock was grazed continuously. The HILF and continuously grazed treatments were stocked at one animal-unit per 5.6 ha between March and December. The six paddocks were located in a Clay Loam range site with slopes less than 4%. Species composition was similar within the six paddocks.

Diet collections and pedometer readings were made at weekly intervals from July 31 to December 18. The animals grazed each HILF paddock for 28 days (a grazing period) before being moved to the adjacent paddock. Diets were sampled and pedometer readings were taken on days 1, 7, 14, 21, and 28 of each grazing period. Travel of two Hereford heifers (one fistulated and one nonfistulated) in each treatment was monitored continuously using a digital pedometer attached to the left foreleg (Anderson and Kothmann 1977). Weight changes from four nonfistulated heifers in both the HILF system and the continuously grazed paddock were evaluated every 28 days.

Every Wednesday the six animals in each treatment were penned before sunrise. The fistulated animals were prepared for diet collection and the digital pedometer readings were taken.

The diet samples collected were analyzed for botanical composition using a quadrant technique (Kothmann 1968). The Kjeldahal procedure described the the Association of Official Agricultural Chemists (1970) was used to determine the organic nitrogen content of the diets. The first stage of the Tilley and Terry (1963) in vitro digestion technique, followed by neutral-detergent (cell-wall) extraction (Van Soest and Wine 1967), were used to determine digestible organic matter values for the diet samples.

Botanical composition of the diet was determined for the following categories: grass leaf blade, grass stem-leaf sheath (leaf sheaths and elongated internodes), forb leaf, forb stem and the floral parts for both plant groups. Three derived categories (grass leaf blade/stem-leaf sheath ratio, total grass and total forbs) were caculated.

Weather data were collected and means of 7-day increments were obtained that corresponded to the 7-day intervals for diet collection and travel data. The weather station was located at the ranch headquarters, approximately 3 km southeast of the research paddocks. Precipitation, temperature, and relative humidity were measured. Daily maximum and minimum temperatures along with maximum and minimum relative humidities were recorded. The moisture content of the air was described as relative humidity, vapor pressure deficit[2] and mixing ratio[3] in order to determine which method would contribute the most to maximum $R^2$ statistical procedures.

Regression equations were developed across periods using maximum $R^2$ selection techniques with animal travel as the dependent variable. Independent variables were seven weather parameters (precipitation, minimum temperature, mean temperature, maximum vapor pressure deficit, minimum relative humidity, maximum mixing ratio, and minimum mixing ratio) and five diet parameters (grass leaf blade/stem-leaf sheath ratio, total grass fragments, total forb fragments, crude protein, and digestible energy). The simple correlation matrix of the seven weather variables was examined and those variables showing a high colineararity were reevaluated and all but one was eliminated from the regression equation. Orthogonal polynomials were used to detect significant trends in travel during the study for both treatments. Homogeneity of regression slopes for animal travel within each period over the 140-day trial was determined using analysis of variance techniques.

## Results and Discussion

Travel of the Hereford heifers in the 20-ha continuously grazed paddock averaged 36.1 km/7 da (standard deviation = 7.3 km/7 da) over the 140-day trial. Heifers in the HILF system traveled significantly less, averaging 25.0 km/7 da (standard deviation = 8.7 km/7 da). The literature would indicate these values lie within the range of daily distances cattle will travel. There was no significant difference in travel between the esophageally-fistulated and nonfistulated heifers in either treatment. Travel across periods showed a statistically significant (continuous $P = 0.40\%$; HILF $P = 0.01\%$) linear decline in both treatments during the 20 weeks. Travel among periods (Fig. 1) did differ significantly under HILF and continuous grazing; however, there was no statistical evidence of nonhomogeneity of slopes for travel within periods in the continuously grazed paddock.

Under continuous grazing, the regression equation developed to describe animal travel ($\hat{y}$) included the following independent variables: grass leaf blade/stem-leaf sheath ratio ($X_{L/S}$), percent crude protein ($X_{CP}$) and digestible energy in kcal/kg ($X_{DE}$).

$$\hat{y} = -32.60 + 1.10 (X_{L/S}) + 292.95 (X_{CP}) + 0.02 (X_{DE}) \quad \textbf{(1)}$$

None of the weather parameters considered contributed to the variability in animal travel. However, the three independent variables grass leaf blade/stem-leaf sheath ratio, crude protein, and digestible energy accounted for 69% of the variability in animal travel per 7 days with levels of significance of 0.50, 0.04, and 0.01%, respectively.

Under HILF grazing, three weather parameters and four diet parameters were included in a regression equation which accounted for 90% of the variability in travel. The independent variables were: precipitation in cm ($X_P$), maxi-

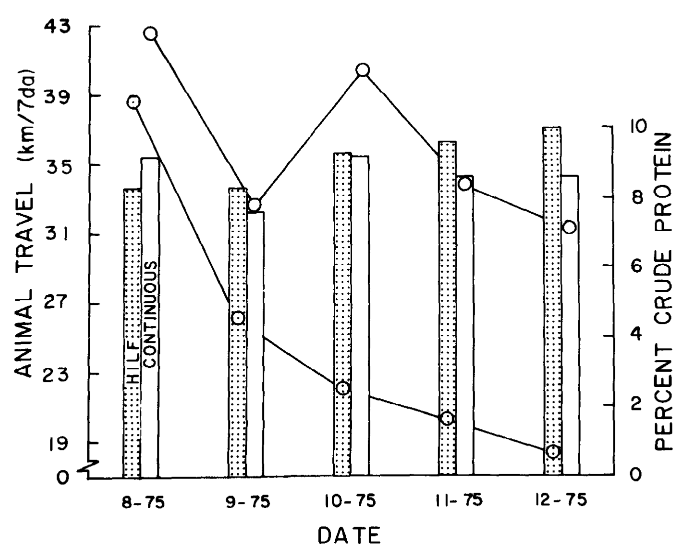


**Fig. 1.** *Animal travel (lines) and percent crude protein (bars) under continuous and high-intensity low-frequency (HILF) grazing on the Texas Experimental Ranch during 1975.*

[1]Kothmann, M.M., ed. 1974. A Glossary of Terms Used in Range Management. 2nd ed. Society for Range Management, Denver, Colo. 36 p.

[2]Vapor Pressure Deficit (vpd) = $(e_s) - [e_s) - (RH)]$
where:
vpd = Vapor pressure deficit expressed in millibars (mb).
es = Saturation vapor pressure (mb) over water at a given temperature (C).
RH = Relative humidity expressed as a decimal equivalent.

[3]*Mixing Ratio (w)* = $(0.622)\ [(e_s)/(P - e_s)]$
where:
w = Is the ratio of the mass of water vapor in the air to the mass of the dry air each expressed in grams.
Note: Maximum mixing ratio occurs at the highest temperature measure for a time period.
0.62 = Molecular weight of water divided by the molecular weight of dry air.
P = Station pressure (mb). Mean value of 981 mb used in calculation take from the National Weather Service located at the municipal airport, Wichita Falls, Tex.

Table 1. Energy cost of horizontal locomotion of Hereford heifers under high-intensity low-frequency (HILF) and continuous grazing management on the Texas Experimental Ranch during 1975.

| Month | (1) Weight (kg) | (2) ADG (kg/da) | (3) Travel (km/7 da) | (4) Diet DE (kcal/kg) | (5) METh (kcal/da) | (6) ME (kcal/da) | (7) (%) |
|---|---|---|---|---|---|---|---|
| | | | High-intensity low-frequency grazing | | | | |
| Aug. | 267 | 0.39 | 38.57 | 2411 | 706 | 5350 | 13 |
| Sept. | 274 | 0.22 | 26.08 | 2330 | 490 | 5350 | 9 |
| Oct. | 287 | 0.49 | 22.01 | 2373 | 433 | 5648 | 8 |
| Nov. | 293 | 0.21 | 20.24 | 2343 | 407 | 5736 | 7 |
| Dec. | 299 | 0.21 | 18.29 | 2414 | 375 | 5824 | 6 |
| $\bar{X}$ | 284 | 0.30 | 25.04 | 2374 | 482 | 5582 | 8.6 |
| ±*S.D.* | ±13 | ±0.13 | ±8.09 | ±38 | ±132 | ±220 | ±2.7 |
| | | | Continuous grazing | | | | |
| Aug. | 298 | 0.33 | 42.45 | 2341 | 867 | 5810 | 15 |
| Sept. | 302 | 0.14 | 32.61 | 2321 | 675 | 5868 | 12 |
| Oct. | 310 | 0.29 | 40.32 | 2392 | 857 | 5984 | 14 |
| Nov. | 323 | 0.46 | 33.69 | 2229 | 746 | 6171 | 12 |
| Dec. | 320 | -0.13 | 31.21 | 2120 | 685 | 6128 | 11 |
| $\bar{X}$ | 311 | 0.22 | 36.06 | 2281 | 766 | 5992 | 12.8 |
| S.D. | ±11 | ±0.23 | ±5.00 | ±107 | ±92 | ±157 | ±1.6 |

1-4 Data collected by Anderson (1977).
5 Metabolizable energy (ME) for horizontal travel (Th) calculated as follows (Ribeiro et al. 1977):
(0.48 kcal ME/kg-km) (km/da) (kg body wt.) = kcal ME/da
6 Metabolizable energy of maintenance ($ME_m$) = (81) ($W/kg^{0.75}$) after (Blaxter 1962).
7 Percent ME needed above basal metabolism for free-raning animals calculated as follows: [(5)/(6)] [(100)]
*S.D.* = Standard Deviation

mum temperature in degrees centigrade ($X_T$), maximum mixing ratio ($X_{MR}$), grass leaf blade/stem-leaf sheath ratio ($X_{L/S}$), percent forbs in the diet ($X_F$), percent crude protein ($X_{CP}$) and digestible energy in kcal/kg ($X_{DE}$).

$$\hat{y} = 64.79 + 6.35\,(X_P) + 2.03\,(X_T) - 1.77\,(X_{MR}) + 0.83\,(X_{L/S}) + 65.83\,(X_F) - 829.59\,(X_{CP}) + 0.06\,(X_{DE}) \quad (2)$$

Beginning with precipitation, the independent variables were significant at the level 0.01, 0.28, 0.09, 4.86, 1.07, 0.01, and 0.03%, respectively.

Crude protein and digestible energy were the common independent variables that correlated with animal travel regardless of the type of grazing management. The accuracy of this association, which was not investigated, depends upon the pacelength to which the pedometers were calibrated and the subsequent categories of animal travel, i.e., foraging, walking, and running that took place during the 140-day trial which may have differed from the calibration pace-length (Anderson and Kothmann 1977).

The Hereford heifers managed under HILF (higher density of animals per unit area) traveled 11.0 km/7da ($P<5\%$) less than the animals under continuous grazing. However, travel under HILF and continuous grazing did not appear to influence average daily gain in a significant way even though the animals under continuous grazing averaged 26.5 kg heavier than those grazing on the HILF system (Table 1). This difference in the mean weight of animals grazing the two treatments was reflected in a significantly ($P < 1\%$) greater (7.35%) metabolizable energy requirement for maintenance under continuous grazing than under HILF (Table 1).

Using Reibeiro's et al. (1977) value for the energy cost of horizontal locomotion, 284 kcal/da ($P< 1\%$) more energy was required under continuous grazing than HILF. The data indicate that the energy cost of horizontal travel during grazing can increase maintenance requirements above the energy required for basal metabolism (National Research Council 1976) by 6 to 15%.

Standing crop heterogenity was observed to influence heifer movement within the paddocks. Flowering American basketflower (*Centaurea americana* Nutt.), flowering heath aster (*Aster ericoides* L.), and grassland pricklypear *(Opuntia macrorhiza* Engelm.) fruits were actively sought out by the grazing heifers when available (Anderson 1977). During the 140 days of the study, standing crop composition became more homogeneous due to loss of ephemeral forbs and perennial plant parts from wind, weathering, and animal activity. Between August and December the proportion of grass leaf blade to stem-leaf sheath component and digestible energy in the diet decreased; however, the diet always contained a higher percent of grass leaf blade than stem-leaf sheath (Anderson 1977). Plant maturity and loss of leaf material due to weathering with advance of season would help to explain this phenomenon. Ruckebusch and Bueno (1978) noted a decrease from November to March in the time 500 kg Aubrac cows spent walking. They attributed this to a decreasing standing crop, leaf material in particular. However, further research will be needed to determine if the similar trends between plant maturity, digestible energy and animal travel reflect a true cause and effect relationship.

Crude protein was positively correlated with distance traveled under continuous grazing and negatively correlated under HILF. Between September and October, animal travel under HILF declined 4.07 km per 7 days, whereas dietary crude protein increased from 8.3 to 9.3%. This was probably due to availability of warm-season vegetation in the second paddock resulting from the 112 days of rest prior to grazing. Mean digestible energy of the diet was 94 kcal/da higher under HILF as compared to continuous grazing (Table 1). This difference approached significance at the 10% level. Crude protein continued to increase under HILF from October to November, while animal travel decreased.

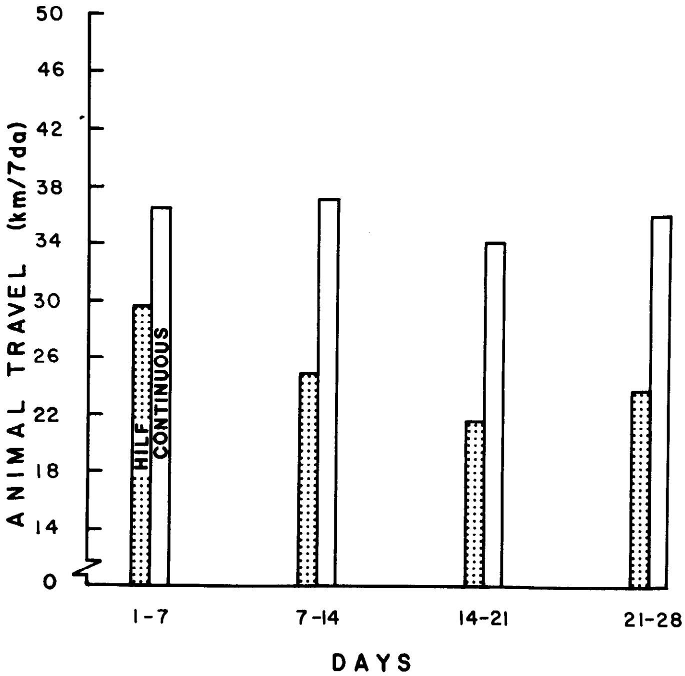


**Fig. 2.** *Mean animal travel within a grazing period (28 days) under continuous and high-intensity low-frequency (HILF) grazing on the Texas Experimental Ranch during 1975.*

Under continuous grazing, crude protein and animal travel followed similar trends.

When palatable forbs were present they were consumed by the animals and the percent of grasses in the diet decreased (Anderson 1977). Under HILF grazing, the percent of forbs in the diet showed a significant linear decline ($P = 0.1\%$) from day 1 to day 28. Travel also decreased during this same time frame (Fig. 2).

Meteorological parameters were significantly correlated with animal travel under HILF grazing. As temperatures decreased within the range 35 to −3° C, travel decreased. From July to December, as the mass of water vapor in the air decreased, as evidenced by the decrease in the numerical value of the maximum mixing ratio, animal travel also decreased. Ruckebusch and Bueno (1978) found that rain and wind interacted with circadian patterns of cow activity by decreasing the time spent walking, especially in paddocks of 0.5-ha size compared to areas 600% larger. The 3-km distance between the animals' location and the weather station added uncertainty to the interpretation of the biological effects of temperature and moisture on animal travel. To identify the cause and effect that may exist between weather parameters and animal travel, micro-meteorological data need to be taken in conjunction with animal travel studies.

Animals restricted to a smaller paddock in a HILF grazing system traveled less compared to continuous grazing, thus reducing the amount of energy expended for travel. Vibracorder data (Ruckebusch and Bueno 1978) help substantiate this hypothesis since the time spent walking and grazing per 24 h was greater in a 3-ha area compared to a 0.5-ha area. Also the patterns of grazing activity were disrupted when cows were restricted to the 0.5 ha area. "Ice cream" species are actively sought and quickly removed from the standing crop under HILF management, thus eliminating one cause for travel. Future travel studies should have several age classes of animal grazing under similar animal densities in paddocks of various size chosen to represent both homogeneous and heterogeneous standing crop composition. In sparse vegetation maintenance energy for travel is high; therefore, studies involving ethology will provide a new dimension in the development of grazing management systems.

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