



Grazing behavior of rangeland beef cattle differing in biological type  
by Richard Neal Funston

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in  
Animal Science

Montana State University

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Abstract:

A research project was conducted during the summers of 1985 and 1986 at the Northern Montana Agricultural Research Center to evaluate differences in grazing behavior exhibited by different lactating beef cow types. The objectives of this project were to measure the major grazing activities (distance traveled and grazing time) and to analyze possible breed type differences in biting rate. Cows were fitted with vibracorders and pedometers, and bite rate estimates were recorded throughout the study period. In 1985, 24 cows were used which consisted of 4 breed groups with 6 cows per breed group. The breed groups consisted of Hereford (HH), 50% Angus-50% Hereford (AH), 50% Simmental-50% Hereford (1S1H) and 75% Simmental-25% Hereford (3S1H). Animals grazed on a 320 ha native foothill grassland with slopes from 5-40% dominated by rough fescue, Idaho fescue and bluebunch wheatgrass on the upland areas and Kentucky bluegrass on the lowland areas. Total daily grazing hours were  $11.8 \pm .2$ ,  $12.3 \pm .2$ ,  $11.6 \pm .2$  and  $11.6 \pm .5$  hr/d for HH, AH, 1S1H and 3S1H, respectively. There was a tendency for AH cows to graze longer than HH and 1S1H ( $P=.10$ ) but the AH did not differ from the 3S1H ( $P>.10$ ). Bite rates were  $52.7 \pm 1.5$ ,  $56.2 \pm 1.5$ ,  $53.2 \pm 1.4$  and  $59.0 \pm 1.6$  bites/m for BH, AH, 1S1H and 3S1H, respectively. The 3S1H had a higher bite rate ( $P<.05$ ) than the HH and 1S1H but not higher than the AH ( $P>.10$ ). The AH had a higher bite rate ( $P<.05$ ) than the 1S1H and the HH but the 1S1H and HH did not differ ( $P>.10$ ). Breed type means for distance traveled were  $3.1 \pm .2$ ,  $3.4 \pm .2$ ,  $4.0 \pm .2$  and  $2.8 \pm .2$  km/d for RH, AH, 1S1H and 3S1H, respectively. The 1S1H cows traveled farther ( $P<.10$ ) than the other three breed groups. The AH traveled farther than the 3S1H but did not differ from the HH. In 1986 the breed groups consisted of Hereford (HH), Tarentaise-Hereford (TH), Tarentaise-Simmental-Hereford (T(SH)) and Charolais-Simmental-Hereford (C(SH)). The breed groups consisted of 6 lactating cows per group. The pasture was 276 ha and was similar in terrain and forage composition to the pasture used in 1985. No differences were found in grazing time among the four breed groups ( $P>.10$ ). The breed group means were  $11.3 \pm .2$ ,  $11.3 \pm .2$ ,  $11.4 \pm .2$ , and  $11.2 \pm .2$  for BH, TH, T(SH) and C(SH), respectively. Breed group means for bite rate were  $56.9 \pm 1.1$ ,  $58.7 \pm 1.1$ ,  $60.9 \pm 1.0$ , and  $59.0 \pm 1.1$  bites/m for BH, TH, T(SH) and C(SH), respectively. The T(SH) had a higher bite rate than the HH ( $P<.10$ ) but did not differ from the TH or C(SH), and the TH and C(SH) did not differ from the HH breed group ( $P>.10$ ). No differences ( $P>.10$ ) were found in distance traveled. Breed group means were  $3.5 \pm .4$ ,  $3.8 \pm .4$ ,  $3.6 \pm .4$  and  $3.6 \pm .4$  km/d for BH, TH, T(SH) and C(SH), respectively. These data indicate that grazing time is independent of breed type. Bite rate does appear to be a behavioral expression that is different among different breed types. This may be a response that allows different breed types to achieve different intake levels.

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A thesis submitted in partial fulfillment  
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MONTANA STATE UNIVERSITY  
Bozeman, Montana

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## ABSTRACT

A research project was conducted during the summers of 1985 and 1986 at the Northern Montana Agricultural Research Center to evaluate differences in grazing behavior exhibited by different lactating beef cow types. The objectives of this project were to measure the major grazing activities (distance traveled and grazing time) and to analyze possible breed type differences in biting rate. Cows were fitted with vibracorders and pedometers, and bite rate estimates were recorded throughout the study period. In 1985, 24 cows were used which consisted of 4 breed groups with 6 cows per breed group. The breed groups consisted of Hereford (HH), 50% Angus-50% Hereford (AH), 50% Simmental-50% Hereford (1S1H) and 75% Simmental-25% Hereford (3S1H). Animals grazed on a 320 ha native foothill grassland with slopes from 5-40% dominated by rough fescue, Idaho fescue and bluebunch wheatgrass on the upland areas and Kentucky bluegrass on the lowland areas. Total daily grazing hours were  $11.8 \pm .2$ ,  $12.3 \pm .2$ ,  $11.6 \pm .2$  and  $11.6 \pm .5$  hr/d for HH, AH, 1S1H and 3S1H, respectively. There was a tendency for AH cows to graze longer than HH and 1S1H ( $P=.10$ ) but the AH did not differ from the 3S1H ( $P>.10$ ). Bite rates were  $52.7 \pm 1.5$ ,  $56.2 \pm 1.5$ ,  $53.2 \pm 1.4$  and  $59.0 \pm 1.6$  bites/m for HH, AH, 1S1H and 3S1H, respectively. The 3S1H had a higher bite rate ( $P<.05$ ) than the HH and 1S1H but not higher than the AH ( $P>.10$ ). The AH had a higher bite rate ( $P<.05$ ) than the 1S1H and the HH but the 1S1H and HH did not differ ( $P>.10$ ). Breed type means for distance traveled were  $3.1 \pm .2$ ,  $3.4 \pm .2$ ,  $4.0 \pm .2$  and  $2.8 \pm .2$  km/d for HH, AH, 1S1H and 3S1H, respectively. The 1S1H cows traveled farther ( $P<.10$ ) than the other three breed groups. The AH traveled farther than the 3S1H but did not differ from the HH. In 1986 the breed groups consisted of Hereford (HH), Tarentaise-Hereford (TH), Tarentaise-Simmental-Hereford (T(SH)) and Charolais-Simmental-Hereford (C(SH)). The breed groups consisted of 6 lactating cows per group. The pasture was 276 ha and was similar in terrain and forage composition to the pasture used in 1985. No differences were found in grazing time among the four breed groups ( $P>.10$ ). The breed group means were  $11.3 \pm .2$ ,  $11.3 \pm .2$ ,  $11.4 \pm .2$ , and  $11.2 \pm .2$  for HH, TH, T(SH) and C(SH), respectively. Breed group means for bite rate were  $56.9 \pm 1.1$ ,  $58.7 \pm 1.1$ ,  $60.9 \pm 1.0$ , and  $59.0 \pm 1.1$  bites/m for HH, TH, T(SH) and C(SH), respectively. The T(SH) had a higher bite rate than the HH ( $P<.10$ ) but did not differ from the TH or C(SH), and the TH and C(SH) did not differ from the HH breed group ( $P>.10$ ). No differences ( $P>.10$ ) were found in distance traveled. Breed group means were  $3.5 \pm .4$ ,  $3.8 \pm .4$ ,  $3.6 \pm .4$  and  $3.6 \pm .4$  km/d for HH, TH, T(SH) and C(SH), respectively. These data indicate that grazing time is independent of breed type. Bite rate does appear to be a behavioral expression that is different among different breed types. This may be a response that allows different breed types to achieve different intake levels.

## INTRODUCTION

Rangelands are one of the Northern Great Plains largest renewable resources and it is primarily through beef cattle production that we achieve an economic gain from these rangelands. Intensive research addressing the interface of beef cattle and rangelands is of great importance to those who utilize rangeland for beef production.

Identification of those breeds or breed types that exhibit a grazing behavior favorable to the efficient utilization of range forage warrants further investigation. Squires (1978) has emphasized that data on general range livestock behavior is available but little attention has been given to the relationship of free ranging activities and subsequent animal performance. To more fully exploit production of beef cows on rangeland, a more complete understanding of their feeding activities is essential. The collection of behavioral data would provide information to complement extensive animal performance data currently being generated by cooperating Montana Agricultural Experiment Station projects in animal breeding and range nutrition.

The major objective of this study was to evaluate the grazing behavior and production characteristics (cow weight, calf weight and milk production) of genotypically different types of beef cattle grazing summer rangeland. The grazing behavior activities studied were time spent grazing, distance traveled and bite rate.

## LITERATURE REVIEW

The focus of this literature review is to examine the relationship of grazing animal response to animal, range and environmental factors.

Animal Factors

Grazing behavioral patterns have been shown to be affected by genotype and physiological status of the grazing animal.

In a year round study, Herbel and Nelson (1966) reported Hereford cows grazed 1.4 hr/d longer, walked 1.3 hr/d less and traveled 4.7 km/d less than Santa Gertrudis cows on New Mexico rangeland ( $P < .05$ ). The Hereford's increased grazing time was at night. Yeates and Murray (1966) conducted walking trials with Hereford and Santa Gertrudis cattle in Australia and found that the Santa Gertrudis had less increase in rectal temperature and respiratory rate than the Hereford cattle in temperatures ranging from 27 to 29 C. It was suggested that the Santa Gertrudis cattle were more heat tolerant and had a lower exercise heat production. This was probably associated with a longer walking stride. This increased heat tolerance enabled the Santa Gertrudis cattle to adapt better to hot climates and travel longer distances. In a study done on arid rangelands in New Mexico, Anderson (1986) found that Hereford cows traveled significantly less ( $P < .04$ ) than Hereford X Santa Gertrudis cows, 6.9 and 7.3 km/d, respectively.

Studies comparing breeds of the same species have shown little differences in grazing activities. In a study conducted in New York using one Hereford and three Angus cows, Johnstone-Wallace and Kennedy

(1944) reported both breeds spent from 7 to 8 hr out of 24 grazing, 7 hr chewing their cud, had a bite rate from 50 to 70 bites/min and traveled an average of 4.02 km/d on pastures ranging from 1.2 to 2.8 ha. Kropp et al. (1973) conducted a study in Oklahoma on behavior of nonlactating heifers and concluded that the behavior patterns and concurrent weight gains of Holstein and Hereford X Holstein heifers were similar to Hereford heifers in range behavior activities of grazing, ruminating, idling, drinking, walking and sleeping. Lathrop (1985) studied four lactating beef cattle types, Hereford (HH), 50% Angus - 50% Hereford (AH), 50% Simmental - 50% Hereford (1S1H) and 75% Simmental - 25% Hereford (3S1H), in northern Montana and found no differences in grazing time but did discover that the 1S1H cows traveled less ( $P < .05$ ) than HH, AH and 3S1H cows. Breed type means were 5.0, 4.8, 4.1 and 4.8 km/d for HH, AH, 1S1H and 3S1H cows, respectively.

Stricklin et al. (1976) conducted a study comparing Angus (A) and Charolais X Angus (CXA) cross cows and found the CXA cows on summer pasture grazed an average of 9.0 hr/d and the A cows grazed 8.5 hr/d ( $P < .01$ ). These differences may be a function of different milk production rather than an inherent breed difference. Lathrop (1985) reported increased grazing time with increased milk production, the partial regression coefficient was .05 hr/d/kg/d. Stobbs (1970) noted a tendency for high milk producers to satisfy their nutritional needs by increasing nighttime grazing on tropical grasslands in Australia. A positive relationship between grazing time and milk production was also reported in both Jersey and Friesian dairy cattle (Brumby, 1959).

Intake and grazing time do not appear to be positively correlated. Zoby and Holmes (1983) studied grazing behavior in small, medium and large frame groups of British Friesian cattle which consisted of 6 dry nonpregnant cows and 2 large steers in the large group, 8 steers in the medium group and 8 steer calves in the small group with mean live weights of 631, 439 and 164 kg for large, medium and small animals, respectively. Grazing time and bite rate was highest for small cattle and lowest for large cattle. Intake and bite size followed an opposite trend with the large animals having the highest intake and bite size and the small animals having the lowest. Forage availability ranged from 1,930 to 5,270 kg/ha. Hendricksen and Minson (1980) also reported a significant linear relationship ( $r^2=.88$ ) between intake and bite size but intake did not have a significant linear relationship with bite rate or grazing time on tropical grasslands of Australia. Wagner et al. (1986) found different ( $P<.01$ ) intake levels, 2.3, 2.5, 2.6 and 2.8% BW/d for HH, AH, 1S1H and 3S1H beef cows, respectively. Lathrop (1985), using the same breed types found no apparent differences in grazing time, supporting the previous studies showing no relationship between intake and grazing time. In a study using nonlactating Hereford, Holstein X Hereford and Holstein heifers Kropp et al. (1973) concluded that grazing time was not highly related to forage intake because in each season the breed with the highest grazing time gained the least weight. Chacon and Stobbs (1976) studied correlations between estimated intake and eating behavior measurements and reported that the major factor influencing estimated intake was bite size. Intake was estimated from the product

of the mean bite rate in non-fistulated cows and the mean bite size of fistulated cows taken in a 24-hr period.

#### Range Factors

Feed intake of grazing animals is a function of time spent eating, bite rate and bite size (Chacon et al., 1976). Grazing time and bite rate are functions of many pasture variables (Chacon and Stobbs, 1976). Some of the variables studied by Chacon and Stobbs (1976) include pasture yield, % leaf, leaf stem ratio and height of forage. Studies involving specific pasture parameters have been inconclusive (Arnold, 1981; Arnold and Dudzinski, 1967 a,b). This section will emphasize availability, a gross measure of amount of forage which includes many of the parameters which are not well understood.

Grazing animals can partially compensate for declining forage availability by changing their grazing behavior. Jamieson and Hodgson (1979) found that as green herbage mass was mechanically reduced from 3,000 to 1,000 kg OM/ ha, biting rates and grazing time of calves and lambs increased but insufficiently to offset the decline in bite size. Intake declined by 24% and 39% for calves and lambs, respectively. Chacon and Stobbs (1976) reported that biting rate in cattle increased significantly ( $P < .05$ ) from 56 to 62.4 bites/min and 51.4 to 59.4 bites/min as available forage decreased from 7,200 to 1,500 kg/ha and 3,900 to 2,400 kg/ha, respectively. Grazing time also increased from 550 to 650 min/d and 525 to 600 min/d, respectively. At lower forage availability, grazing time, bite rate and bite size declined, resulting in lowered forage intake. Peak grazing time and highest

number of bites occurred when leaf yields averaged 1,000 kg DM/ha. In the later stages of defoliation, grazing time, eating bites and bite size declined, resulting in a lower intake level. Allden (1970) found that at greater tiller lengths the size of bite and rate of biting in sheep varied inversely to maintain a constant rate of intake. When accessibility of herbage imposed limitations on the rate at which the animal was able to prehend its food, sheep partially compensated for the reduced amount of forage by an increase in grazing time (from 6 to 13 hr/d). However, as an animal extended its period of grazing the compensation became progressively more incomplete. Allden (1970) reported a relatively constant rate of intake and grazing time at forage availability greater than 3,000 kg/ha, but a fourfold decrease in intake and a twofold increase in grazing time was observed as forage availability declined from 3,000 to 500 kg/ha. Zoby and Holmes (1983) reported significantly higher ( $P < .05$ ) grazing time and bite rate, 9.25 hr/d and 68.6 bites/min, respectively, under low forage availability, 2,140 kg DM/ha, when compared to grazing time and bite rate, 8.4 hr/d and 59.8 bites/min, respectively, under higher forage availability, 4,470 kg DM/ha.

Few studies have been reported on the behavioral response to forage availability less than 1,000 kg/ha. As a standing crop of crested wheat grass was grazed by Angus heifers from 417 to 203 kg dry matter/ha, grazing time increased from 458 to 602 min/d, and biting rate increased from 54 to 63 bites/min (Scarnecchia et al., 1985). When pasture yields are low, bite size limited animals from achieving maximum forage intake (Stobbs, 1973), and when mature pasture yields

are high maximum forage intake was not achieved due to difficulty in harvesting enough forage which resulted in long grazing times (Stobbs, 1970). Intake per hour of grazing decreased rapidly as grazing time increased on pastures of low availability and lower intake per bite was not fully compensated by an increase in biting rate (Arnold, 1964). One factor which may limit behavioral responses and subsequent intake is fatigue. Stobbs (1975) reported fatigue limits at 720 minutes of grazing and 36,000 bites in a 24 hr period. Grazing times reported by Scarnecchia et al. (1985) were 90.4% of the fatigue limits reported by Stobbs (1975).

Forage availability also affects the distance traveled by the grazing animal. Quinn and Hervey (1970) reported that in lightly grazed 20.2 ha pastures, yearling cattle averaged 2.8 km/d compared to 3.7 km/d in moderate and heavily grazed pastures. The lesser amount of travel in the light-use pasture appeared to be the result of more available forage. Though distances were similar, the pattern of travel differed between moderate and heavily grazed pastures. The steers in moderately grazed pastures spent more time lying down but their high amount of travel was due to a failure to graze when moving to water or from one area to another. The steers on the heavily grazed pastures spent more time grazing because the forage was not as abundant as in the other pastures. Peterson and Woolfolk (1955) discovered similar results for Hereford cows under different forage availability. Areas with higher available forage had less travel than areas with lower forage availability. Under two different grazing systems, high-intensity-low-frequency (HILF) and continuous grazing, Anderson and



Kothmann (1980) reported that Hereford heifers under the HILF traveled 1.6 km/d less ( $P < .05$ ) than the animals under continuous grazing. The HILF consisted of five 4-ha paddocks and the continuous system consisted of one 20-ha paddock. Crude protein and digestible energy were the common independent variables that correlated with animal travel regardless of the type of grazing management. Walker et al. (1985) found that cattle under short duration grazing tended to walk farther with more animal variation than animals on a continuous grazing system. The pastures in this experiment were from 28 to 39 ha in the short duration grazing systems and 242 ha in the continuous grazing system. Difference in travel under these two systems was probably due to forage availability and not pasture size as in the experiment conducted by Anderson and Kothmann (1980).

#### Environmental Factors

The environment of the grazing animal may influence its grazing behavior. Temperature and humidity affect the physiology of animals and thus influence their activities including grazing behavior. Ehrenreich and Bjugstad (1966) used a temperature humidity index (THI) to incorporate both temperature and humidity and found a highly significant multiple correlation of .968 between THI and time spent grazing. Grazing time also increased when wind speed increased on hot, humid days. In an experiment conducted in Colorado from April to October, Rittenhouse and Senft (1982) found that grazing time was maximal when daily temperature coincided with an acclimated temperature (a 12-day running temperature mean). Any deviation from the acclimated temperature regime resulted in a decrease in grazing

time. A low to intermediate increase in barometric pressure resulted in a rapid increase in grazing time; however, when high pressure changes were observed grazing time decreased gradually. Dwyer (1961) found a decrease in grazing time with increasing temperature. Three different temperature levels were studied: below 27 C, 27-29 C and above 29 C. The grazing means were 8.70, 7.98 and 6.65 hr/d, respectively. Adverse winter weather may also decrease grazing time. Adams et al. (1986) discovered that when minimum daily temperature (MDT) ranged from 0 to -35 C the simple correlation between MDT and daily grazing time was .60 ( $P < .01$ ).

Cattle prefer to graze in daylight and it is only when the hours of light become short or when daytime temperatures are too high for comfort that cattle spend an appreciable part of their grazing time in darkness (Hancock, 1953). Hancock (1953) also found a positive relationship with length of day and daylight grazing time. Ruckebusch and Bueno (1978) found similar results. They reported that time of onset and reset of grazing was correlated (.89) to the corresponding times of sunrise and sunset.

The environment also effects the distance a grazing animal travels and subsequent use of the rangeland. Rain and wind interact with cattle activities to decrease the time spent walking (Ruckebusch and Bueno, 1978). Anderson and Kothmann (1980) found that under a high-intensity-low-frequency grazing system, as temperature decreased within the range of 35 to -3 C subsequent travel decreased. On semi-arid and arid rangelands the location of water had a dominant effect on use of vegetation. On these rangelands water was often restricted

to one or two locations and degree of use of vegetation decreased linearly or exponentially from a water source (Arnold and Dudzinski, 1978). Mueggler (1965) reported that percent slope and distance upslope accounted for 81% of the variation in relative grazing use on mountainous livestock range in southwestern Montana.

## MATERIALS AND METHODS

The study was conducted during the summers of 1985 and 1986 on mountain foothill rangeland in the Bear Paw Mountains, 32 km southeast of Havre, Montana, in cooperation with the Northern Agricultural Research Center. The study site had an average elevation of 1,300 m with slopes ranging from 5 to 40%. Long term annual precipitation ranged from 45.7 to 50.8 cm. The major grasses on the study site were rough fescue (Festuca scabrella), Idaho fescue (Festuca idahoensis) and bluebunch wheatgrass (Agropyron spicatum) on the upland areas and Kentucky bluegrass (Poa pratensis) on the lowland areas.

In 1985, 24 cows of four breed types were used; 6 each of straight Hereford (HH), 50% Angus - 50% Hereford (AH), 50% Simmental - 50% Hereford (1S1H) and 75% Simmental - 25% Hereford (3S1H). The cows ranged in age from 6 to 9-yr-old and were selected at random (within breed type) from the cow herd. All cows were lactating and from a common management background. All calves were sired by Hereford bulls. The pasture used in 1985 was approximately 320 ha in size and contained 250 lactating cows from July 22 to September 16 for a stocking rate of .67 ha/AUM. Water was available at three areas in the pasture (Figure 1). The distance between the reservoir and the creek was approximately 1.6 km.

The 24 cows were equipped with vibracorders, as described by Stobbs (1970), to estimate grazing time. Vibracorders remained on the animals from July 23 to September 16. Charts were changed and clocks were rewound at approximately 9-d intervals. Portable corrals at watering areas were used to minimize animal disturbance when

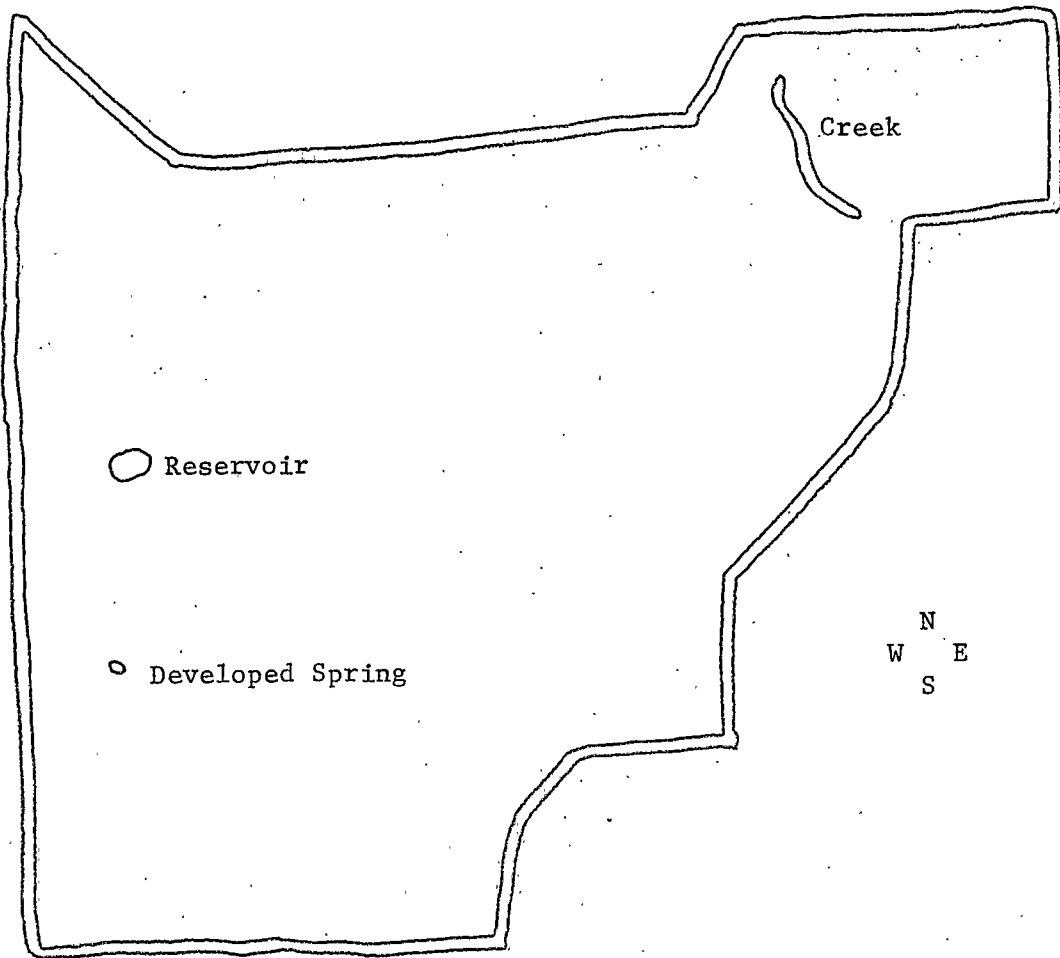


Figure 1. Map of pasture during 1985, 1" = 442m.

vibracorders were changed. On days when equipment was changed, grazing times were disregarded. Each day's grazing time was divided into eight 3-hr periods (2400-0300, 0300-0600, 0600-0900, 0900-1200, 1200-1500, 1500-1800, 1800-2100 and 2100-2400). Grazing time was also divided into two levels of grazing within each period. Level one grazing was defined as any solid marks of 15 min or greater. Level two grazing was defined by intermittent marks with spaces less than 15 min apart.

Distance traveled was estimated by the use of pedometers (Anderson and Kothmann, 1977). Pedometers were read and reset each time vibracorders were changed. Calibration factors were not calculated in 1985 but in 1986 the cows were walked a known distance from one corral to another, then readings were taken and pedometers reset. The cattle were then walked back to the original corral and readings were again taken. The calibration factors for both distances were then averaged to compute a final calibration factor for each cow. Since the same type of pedometer was used both years, the calibration factors for 1986 were averaged and used in 1985. The average calibration factor used in 1985 was .894. This factor was multiplied by the actual pedometer readings and then divided by the number of days the pedometer was on the animal to estimate distance in km/d.

Bite rate measurements were taken throughout the experiment. Bite rate (bites/min) was calculated by counting the number of bites in a 5-min time period. A watch with an independent 5-min timer and stopwatch was used. The stopwatch was stopped when an animal quit biting and the observation was concluded when the 5-min alarm sounded.

A hand held counter was used to count the number of bites. The number of bites was then divided by the stopwatch time to calculate bites/min. A telescope was used to watch the cows early in the season until they could be approached on horseback without disturbance. Bite rates were only taken from 0600-0900 and 1800-2100, these two periods were identified by (Lathrop, 1985) as the major diurnal grazing periods. Commercially available stock dye was used to number all cows so animals could be identified from a distance.

Milk production, calf weights and cow weights were taken twice in 1985 and three times in 1986 during the experiments. Test days were August 2 and 29, 1985 and July 18, August 22 and September 30, 1986. Milk production was estimated using the weigh-suckle-weigh technique (Williams et al., 1979). A 9 or 10 hr cow-calf separation interval was used prior to measuring milk production and cow and calf weights. Milk production was then converted to a 24-hr basis.

In 1986, 24 lactating cows were also used but three new breed groups were added to the HH breed group; Tarentaise - Hereford (TH), Tarentaise - Simmental - Hereford (T(SH)) and Charolais - Simmental - Hereford (C(SH)). The TH were six 50% Tarentaise - 50% Hereford cows, the T(SH) consisted of three 50% Tarentaise - 25% Simmental - 25% Hereford and three 50% Tarentaise - 37.5% Simmental - 12.5% Hereford cows and the C(SH) group contained five 50% Charolais - 25% Simmental - 25% Hereford cows and one 50% Charolais - 37.5% Simmental - 12.5% Hereford cow. Cows were all 3-yr-old and the calves were all sired by Hereford bulls. The pasture in 1986 was approximately 276 ha and contained 56 cows from June 1 to October 1 for a stocking rate of 1.2

ha/AUM. Water was available in three locations (Figure 2). The distance between reservoir 1 and the stock tank was approximately 1.5 km.

In addition to grazing time, distance traveled and bite rate, forage availability was measured periodically throughout the experiment from August 5 to September 12 in 1986. At the time bite rate observations were taken cows were randomly chosen and forage availability was estimated in the area where bite rate was observed. Availability was estimated by clipping four .18 meter rings thrown from the center of the grazing area. Forage was clipped 2 cm from the ground and grasses, forbs and shrubs were separated and bagged separately. The samples were then dried in a 500 watt microwave oven. Forage availability was then converted to a kg/ha basis.

Data were analyzed by least-squares analysis of variance using GLM procedures of Statistical Analysis Systems (SAS) (1985). Differences between means were tested using the least significant difference method (SAS, 1985).

A mixed model was used for analysis of grazing time, distance traveled and bite rate. The linear mathematical model was as follows:

$$Y_{ijk} = u + B_i + I_j + BI_{ij} + C(BI_{ij})_k + e_{ijkl}$$

where

$Y_{ijkl}$  = an observation (grazing time, distance traveled or bite rate),

$u$  = the overall mean,

$B_i$  = the fixed effect of the  $i$ th breed type,

$I_j$  = the fixed effect of the  $j$ th sex of calf,



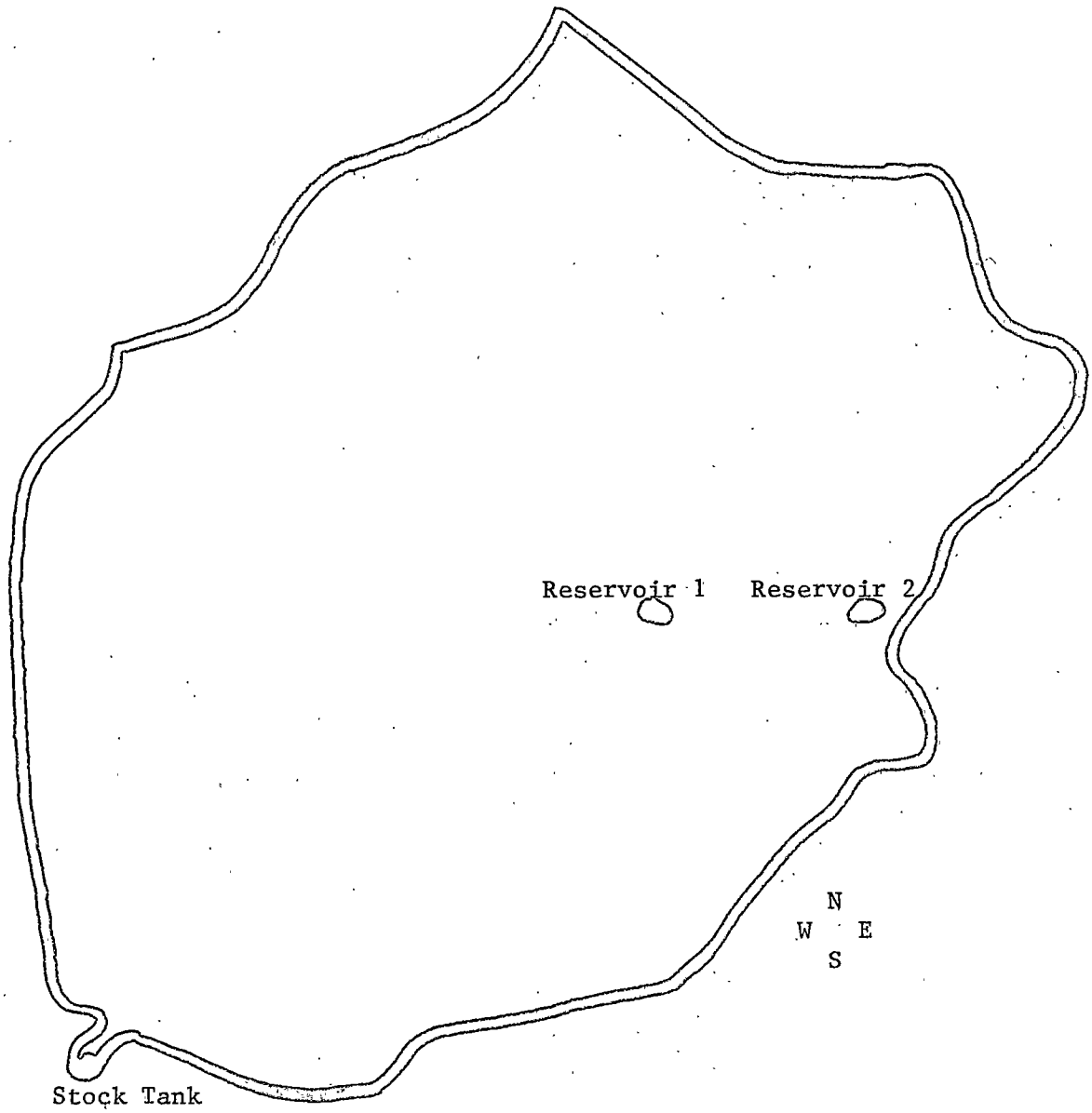


Figure 2. Map of pasture during 1986, 1" = 348m.

$BI_{ij}$  = the interaction between the  $i$ th breed type and the  $j$ th calf sex,

$C(BI_{ij})_k$  = the random effect of the  $k$ th cow within the  $ij$ th BI interaction,

$e_{ijkl}$  = random error.

The random effect of  $C(BI_{ij})_k$  was used as the error term to test the fixed effects, calf sex and breed x calf sex interaction because of repeated measurements taken on each animal (Gill and Hafs 1971). Grazing time was also tested by intensity of grazing.

The linear and quadratic effect of day was added to the above model and tested with the residual as the error term in all three types of observations. In the bite rate analysis time of day (am or pm) of the observation, observer, observer by breed interaction and breed by day interaction were added to the model as independent variables.

The three observations (grazing time, distance traveled and bite rate) were averaged to determine if the production covariates (average cow weight, average weight:height ratio, average calf weight, average milk production, cow condition score, calf condition score and calf age) had any effect on the dependent variables.

Production characteristics (cow weight, milk production and calf weight) were also analyzed. They were analyzed as dependent variables and tested using the first model described with test day and breed x test day interaction added.

## RESULTS AND DISCUSSION

1985 Production Characteristics

The primary reason for measuring production characteristics was to verify that the different breed types used in the study have different production potential as reported by previous research at the same location (Casebolt, 1984; Lathrop, 1985). The least-squares analyses of variance for cow body weight, calf weight and milk production are presented in Table 1. The breed type means and standard errors for these traits are listed in Table 2.

The breed x test day interaction was found to be nonsignificant ( $P > .10$ ) for cow weight and milk production. The interaction was significant ( $P < .10$ ) for calf weight but the interaction was due to a change in magnitude rather than a change in rank.

Calf sex and breed x calf sex interaction were not significant for any of the production measurements. The least-squares means for milk production, cow body weight and calf weight were  $10.6 \pm .8$  and  $9.6 \pm .8$ ,  $589 \pm 18$  and  $605 \pm 18$  and  $183 \pm 7$  and  $172 \pm 7$  kg for steer and heifer calves, respectively.

Cow body weight was not significantly different among the four breed types. The ranking of the breed types agrees with that reported by Lathrop (1985). Lathrop found that the HH cows were lighter ( $P < .01$ ) than the Simmental cross cows.

The Simmental cross cows had heavier calves than the HH cows but the 1S1H cows did not differ from the AH cows in calf weight. The HH and AH did not differ in calf weight. These rankings also tend to follow the results found by Lathrop (1985).

Table 1. Least-squares analyses of variance for cow body weight (BW), calf weight (CW) and milk production (MP) (1985)

Source	df	Mean squares		
		BW (kg) <sup>2</sup>	CW (kg/d) <sup>2</sup>	MP (kg) <sup>2</sup>
Breed type	3	6062.2	2080.0 <sup>+</sup>	31.7 <sup>*</sup>
Calf sex	1	2183.6	1418.7	13.1
Test day	1	1351.5 <sup>*</sup>	10299.0 <sup>*</sup>	.02
Cow(breed x calf sex)	19	5088.6 <sup>*</sup>	778.5 <sup>*</sup>	10.1 <sup>*</sup>
Breed x test day	3	90.0	24.3 <sup>+</sup>	7.9
Residual	20	55.6	8.6	4.3
R <sup>2</sup>		.99	.99	.81

+ P&lt;.10

\* P&lt;.05

Table 2. Least-squares means and standard errors for body weight (BW), calf weight (CW) and milk production (MP) (1985)

Breed type <sup>a</sup>	N	BW (kg)	CW (kg)	MP (kg/d)
HH	6	570 ± 28 <sup>b</sup>	166 ± 7 <sup>c</sup>	7.6 ± 1.2 <sup>c</sup>
AH	6	586 ± 22 <sup>b</sup>	171 ± 7 <sup>cd</sup>	9.6 ± 1.0 <sup>cd</sup>
1S1H	6	608 ± 22 <sup>b</sup>	184 ± 7 <sup>de</sup>	11.8 ± 1.0 <sup>d</sup>
3S1H	6	623 ± 28 <sup>b</sup>	197 ± 7 <sup>e</sup>	11.4 ± 1.2 <sup>d</sup>

<sup>a</sup>H = Hereford, A = Angus, S = Simmental.<sup>b</sup>Body weight (P>.10).<sup>cde</sup>Means in columns with different superscripts differ (P<.10).

Milk production for the Simmental cross was significantly higher than milk production for the HH cows but not different from the AH cows. Casebolt (1984) found that the 1S1H and AH cows had higher milk production than the 3S1H cows ( $P < .05$ ). The HH cows also showed the lowest milk production. Lathrop (1985) found that in the early stages of lactation the Simmental cross cows were higher in milk production than the HH or AH cows. In the study by Casebolt (1984) many more observations were taken on milk production so the differences between studies may be due to sample size.

#### Time Spent Grazing

The least-squares analysis of variance for total daily grazing hours is presented in Table 3. The overall daily grazing mean was 11.9 hr/d with a standard deviation of 1.1 hr/d (649 observations with an average of 27 daily grazing observations per cow). This is higher than the overall grazing mean of 9.4 hr/d reported by Lathrop (1985) using the same four breed types. The differences are probably due to environment, mainly forage availability.

Total daily grazing hours were  $11.8 \pm .2$ ,  $12.3 \pm .2$ ,  $11.6 \pm .2$  and  $11.6 \pm .5$  hr/d for HH, AH, 1S1H and 3S1H cows, respectively. There was a tendency for AH cows to graze longer than the HH and 1S1H cows ( $P = .10$ ) but they did not differ from the 3S1H cows ( $P > .10$ ). When looking at the breed type means, these differences appear small and may not be biologically significant. Lathrop (1985) found no significant differences in total daily grazing time using the same four breed types at the same location.

Table 3. Least-squares analysis of variance for total daily grazing time (1985)

Source	df	Mean squares
		(hr/d) <sup>2</sup>
Breed type	3	15.34
Cow(breed)	18	6.35*
Regression of day		
Linear	1	66.61**
Quadratic	1	57.53**
Residual	625	1.53
R <sup>2</sup>		.37

\* P&lt;.05

\*\* P&lt;.01

Breed types were also tested for differences among levels of grazing intensity but there was no significant effect ( $P>.10$ ). No production covariates or calf sex were significant in explaining variation in grazing time. Lathrop (1985) found that calf age and cow milk production had an effect on grazing time. Other researchers have found no effect of milk production on grazing time (Johnstone-Wallace and Kennedy, 1944; Hancock 1950; Johnstone-Wallace, 1951). Calf age is an indication of stage of lactation of the cow with older calves being in later stages of lactation when milk production is lower. All calves were over 60 d old when milk production was measured. Casebolt (1984) showed that milk production decreased linearly after 60 d of

age, milk production and calf age should be negatively correlated. Conflicting research results addressing the effect of milk production on grazing time indicates that this relationship is not well understood.

Figure 3 illustrates the effect of day of the year on total daily grazing time. As season progressed from day 200 to day 260 grazing time increased to a maximum of approximately 12.5 hr and then leveled off. This year average precipitation was 12.4 cm compared to an average precipitation of 46 - 51 cm, so we assume declining forage availability with time. Research has shown that under declining forage availability grazing time increases (Allden, 1970; Chacon and Stobbs, 1976; Jamieson and Hodgson, 1979; Zoby and Holmes, 1983; Scarneccchia et al., 1985).

Stobbs (1975) estimated that grazing time is limited by fatigue. Fatigue limits were estimated at approximately 12 hr/d grazing. This is supported by the maximum grazing time in Figure 3.

#### Time of Day Grazing

The least-squares analysis of variance for the time of day grazing is presented in Table 4. Breed type was not significant for time of day grazing. Each period was also analyzed for breed effect and no breed effect was found for any period. Figure 4 shows the overall time of day grazing means. The major periods of grazing occurred from 600-900 hr and 1800-2100 hr. These time periods were also identified as the major grazing periods by Lathrop (1985) using the same breed types. Other researchers have found similar grazing patterns for cattle on summer pasture (Dwyer, 1961; Kropp et al.,

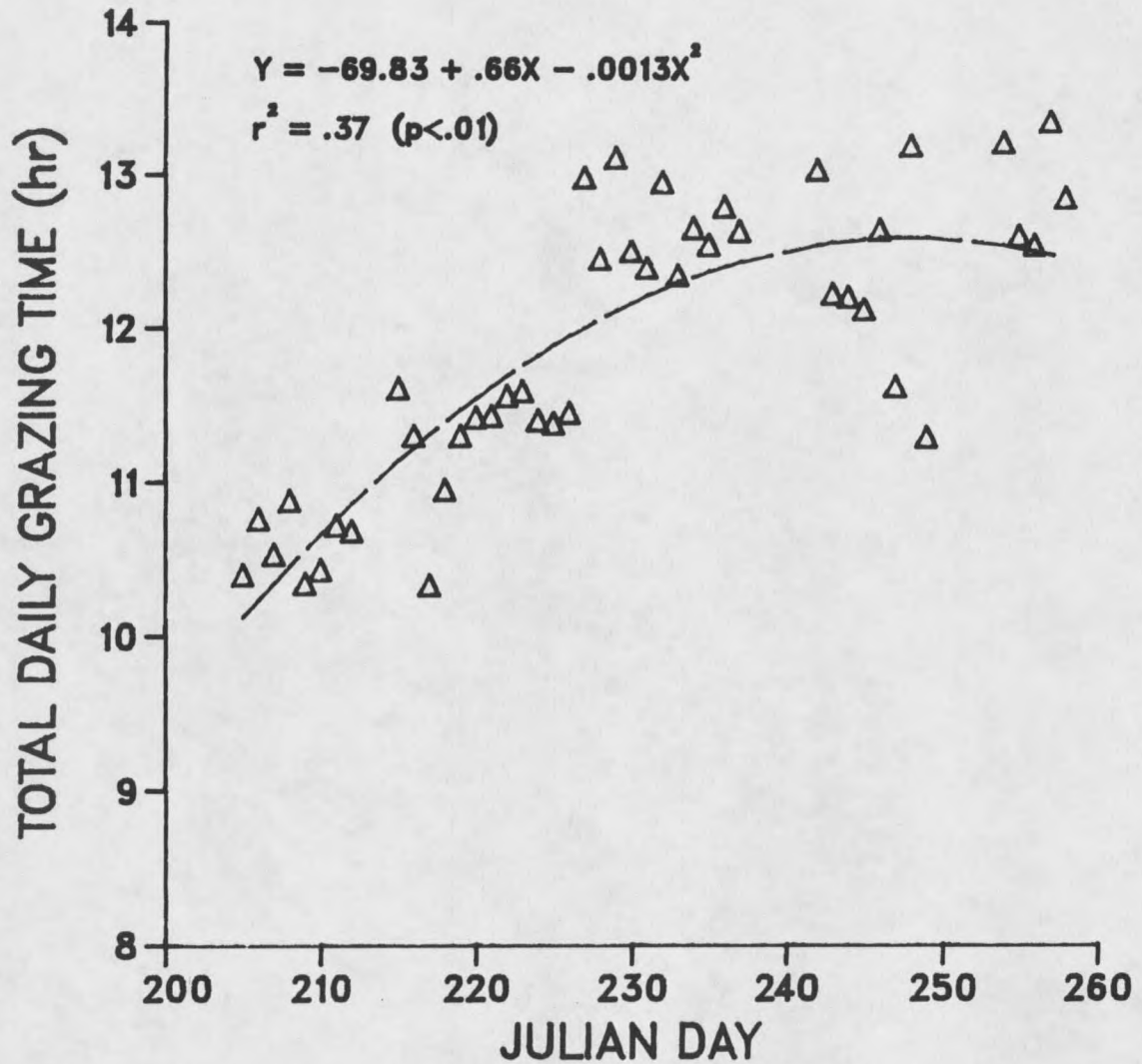


Figure 3. Effect of day of the year on total daily grazing time during 1985. Triangles indicate daily grazing means.



1973; Arnold and Dudzinski, 1978; Zoby and Holmes, 1983).

Table 4. Least-squares analysis of variance for time of day grazing (1985)

Source	df	Mean squares
		(hr) <sup>2</sup>
Breed type	3	1.6
Grazing time period	7	312.7*
Cow(breed)	18	1.0*
Residual	5163	.5
R <sup>2</sup>		.46

\* P<.05

#### Bite Rate

The least-squares analysis of variance for bite rate is presented in Table 5. An average of 8 bite rate observations were taken per cow. Breed was a significant source of variation for bite rate. The least-squares means for bite rate were  $52.7 \pm 1.5$ ,  $56.2 \pm 1.5$ ,  $53.2 \pm 1.4$  and  $59.0 \pm 1.6$  for HH, AH, 1S1H and 3S1H, respectively. The 3S1H had a higher bite rate (P<.05) than the HH and 1S1H but did not differ from the AH (P>.10). The AH had a higher bite rate (P<.05) than the 1S1H and the HH but the 1S1H and HH did not differ (P>.10).

Time of day in which the bite rate measurements were taken was also a significant form of variation. The bite rate measurements taken from 1800-2100 hr were higher than the bite rate measurements taken from 600-900 hr,  $56.3 \pm .7$  and  $54.3 \pm .7$  bites/min,

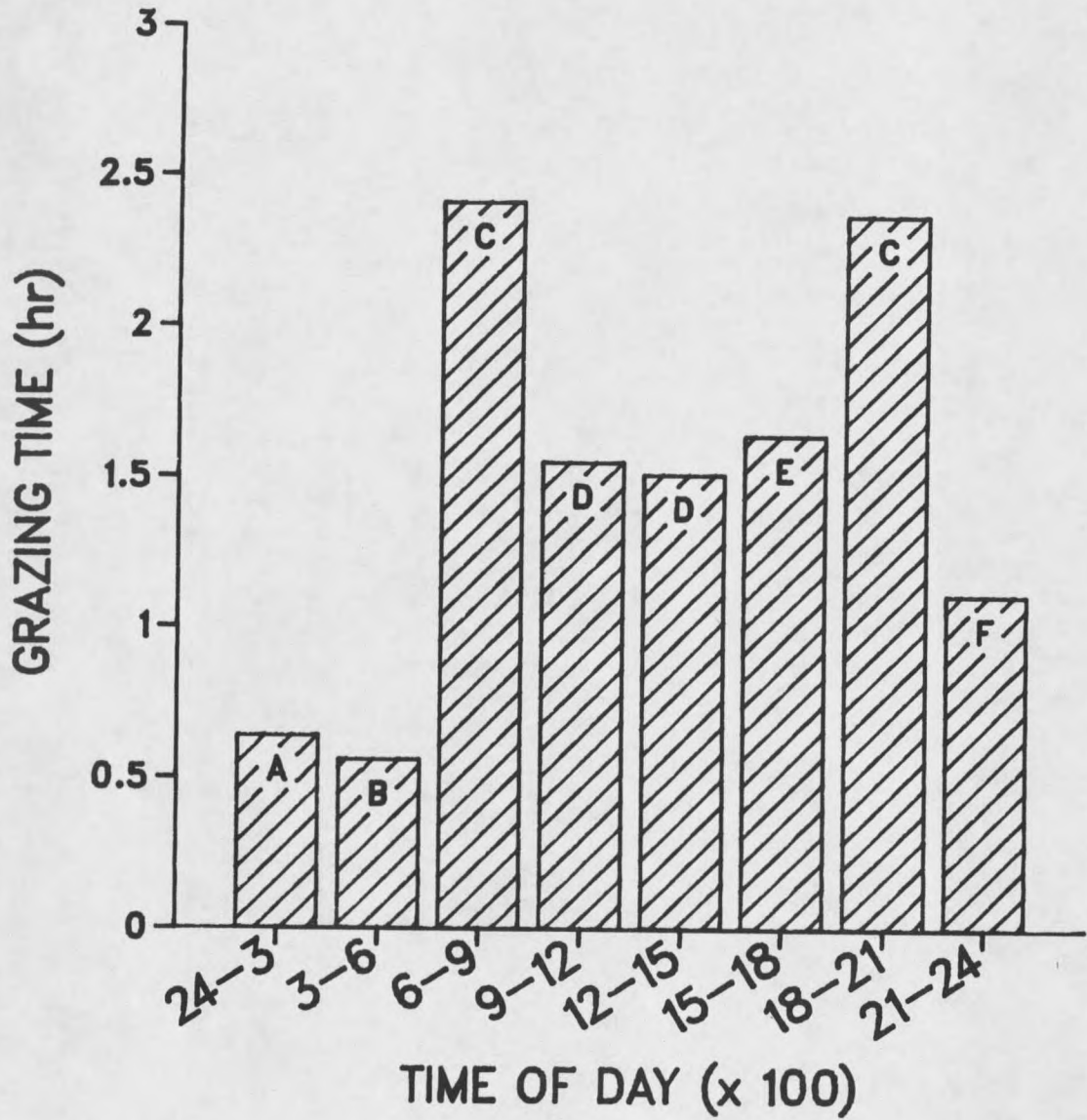


Figure 4. Time of day grazing during 1985. Bars with different letters differ ( $P < .05$ ).

respectively.

Observer also differed in bite rate observations but the observer x breed interaction was not significant. Observer 2 reported higher bite rates than did observer 1,  $59.3 \pm .7$  and  $51.3 \pm .9$  bites/min, respectively.

Breed x linear regression on day interaction was tested and found to be nonsignificant ( $P > .10$ ) so regressions were pooled across breed types and Figure 5 shows the effect of day on bite rate. As season progressed from day 210 to day 260 bite rate increased linearly. Other researchers have shown that as forage availability declines bite rate increases (Chacon and Stobbs, 1976; Jamieson and Hodgson, 1979; Zoby and Holmes, 1983; Scarnecchia et al., 1985). Therefore, declining forage availability could have caused the observed increase in bite rate. None of the production covariates or calf sex were significant in the bite rate analysis.

#### Distance traveled

The least-squares analysis of variance for distance traveled is presented in Table 6. An average of 6 pedometer readings per cow were taken in 1985. Breed type was significant in this analysis and the breed means for distance traveled were  $3.1 \pm .2$ ,  $3.4 \pm .2$ ,  $4.0 \pm .2$  and  $2.8 \pm .2$  km/d for HH, AH, 1S1H and 3S1H cows, respectively. The 1S1H cows traveled significantly farther ( $P < .10$ ) than the other three breed types. The AH traveled farther than the 3S1H but did not differ from the HH. This relationship is opposite of what Lathrop (1985) found where 1S1H cows traveled less than the other three breed types these differences were probably due to the differences in years. The breed

Table 5. Least-squares analysis of variance for bite rate (1985)

Source	df	Mean squares
		(bites/min) <sup>2</sup>
Breed type	3	347.4 <sup>*</sup>
Cow(breed)	20	89.2 <sup>*</sup>
Time of day	1	143.1 <sup>+</sup>
Observer	1	1878.1 <sup>*</sup>
Linear regression on day 1		4424.1 <sup>*</sup>
Residual	160	43.0
R <sup>2</sup>		.68

<sup>+</sup> P<.10

<sup>\*</sup> P<.05

type means were  $5.0 \pm .2$ ,  $4.8 \pm .2$ ,  $4.1 \pm .2$  and  $4.8 \pm .2$  km/d for HH, AH, 1S1H and 3S1H, respectively. None of the production covariates, calfsex, or linear or quadratic regressions on day were significant ( $P>.10$ ) in the distance traveled analysis.

#### 1986 Production Characteristics

Limited data have been collected comparing the production characteristics of the four breed types used in 1986. The Tarentaise and Charolais breeds are relatively new breeds to this research on maternal traits at the Northern Agricultural Research Center at Havre, Montana. The Tarentaise breed was chosen because it is a smaller breed than Simmental with relatively high milk production. Consequently the Tarentaise breed may require less energy intake and still have sufficient milk production.

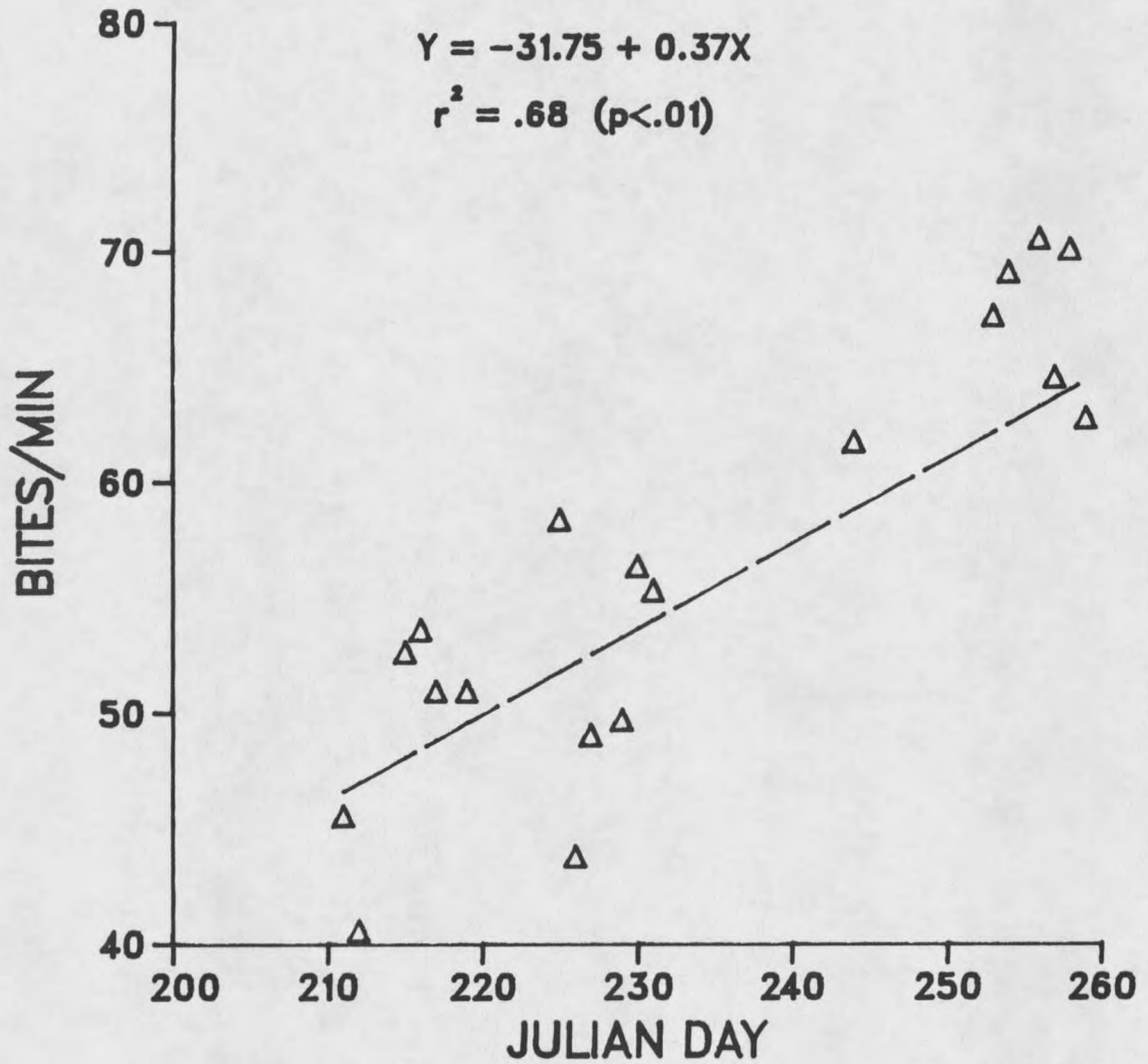


Figure 5. Effect of day of the year on bite rate during 1985. Triangles indicate daily bite rate means.

Table 6. Least-squares analysis of variance for distance traveled (1985)

Source	df	Mean squares
		(km/d) <sup>2</sup>
Breed	3	4.0*
Cow(breed)	20	.6
Residual	114	.5
R <sup>2</sup>		.31

\* P&lt;.05

The least-squares analyses of variance for cow body weight, calf weight and milk production for the animals used in the study are presented in Table 7 and the least-squares means and standard errors are presented in Table 8. The breed x test day interaction was not significant (P>.10) for cow body weight and milk production, but was significant (P<.10) for calf weight. The HH breed was lower on all test days than any of the other breeds. The HH breed was removed from the analyses and the interaction was not significant. The interaction was due to the HH breed responding differently than the other three breed types on the test days.

Calf sex and breed x calf sex interaction were not significant (P>.10) for any of the production characteristics except milk production where calf sex was significant. The heifer calves had dams with higher milk production than the steer calves (P<.05). The least-squares means for milk production, cow body weight and calf weight

were  $6.8 \pm .3$  and  $8.6 \pm .3$ ,  $534.2 \pm 11.5$  and  $549.7 \pm 10.5$  and  $173.5 \pm 5.9$  and  $171.7 \pm 6.5$  kg for steer and heifer calves, respectively. Casebolt (1984) also reported that the dams of heifer calves had higher milk production than dams of steer calves. He also indicated that there was research both supporting and contradicting this finding, and it appears that the relationship is not well understood.

Table 7. Least-squares analyses of variance for cow body weight (BW), calf weight (CW) and milk production (MP) (1986)

Source	df	Mean squares		
		BW (kg) <sup>2</sup>	CW (kg/d) <sup>2</sup>	MP (kg) <sup>2</sup>
Breed type	3	10910.3 <sup>+</sup>	4582.7 <sup>+</sup>	18.2 <sup>*</sup>
Calf sex	1	4086.5	134.8	49.5 <sup>*</sup>
Test day	2	8594.1 <sup>*</sup>	25722.9 <sup>*</sup>	11.6 <sup>*</sup>
Cow(breed x calf sex)	19	4004.3 <sup>*</sup>	1263.6 <sup>*</sup>	3.8
Breed x test day	6	176.4	97.9 <sup>+</sup>	4.3
Residual	40	92.8	17.0	2.9
R <sup>2</sup>		.97	.99	.64

<sup>+</sup> P < .10

<sup>\*</sup> P < .05

Table 8. Least-squares means and standard errors for body weight (BW), calf weight (CW) and milk production (MP) (1986)

Breed type <sup>a</sup>	N	BW (kg)	CW (kg)	MP (kg/d)
HH	6	535 ± 16 <sup>b</sup>	154 ± 7 <sup>b</sup>	6.4 ± .5 <sup>b</sup>
TH	6	532 ± 15 <sup>b</sup>	168 ± 7 <sup>bc</sup>	8.5 ± .5 <sup>c</sup>
T(SH)	6	530 ± 16 <sup>b</sup>	185 ± 7 <sup>c</sup>	8.5 ± .5 <sup>c</sup>
C(SH)	6	572 ± 16 <sup>c</sup>	179 ± 7 <sup>c</sup>	7.5 ± .5 <sup>bc</sup>

<sup>a</sup>H = Hereford, T = Tarentaise, C = Charolais.

<sup>b</sup><sub>c</sub> Means in columns with different superscripts differ (P<.10).

The C(SH) cows had significantly heavier body weights than the other three breed types. The HH cows had calves that were lighter than the T(SH) and C(SH) breed types but were not different from the TH. This is probably due to increased heterosis and increased growth from the Simmental breed influence. The TH and the T(SH) cows had higher milk production than the HH cows (P<.05) but did not differ from the C(SH) cows. Thus the Tarentaise influence was to increase milk production in the cows when compared to Hereford and possibly Charolais which ranked lower though not significantly.

#### Time Spent Grazing

The least-squares analysis of variance for total daily grazing hours is presented in Table 9. The overall daily grazing mean was 11.3 hr/d with a standard deviation of 1.0 hr/d (606 observations with an average of 25 daily grazing measurements per cow). This was slightly lower than the previous year (11.9 hr/d) and is probably due to better environment, primarily forage availability.











































