Growth patterns of beef calves on western rangeland over discreet intervals in the grazing season
by Steven Bennett Church

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

Abstract:
Growth data from 1014 Angus x Hereford (AH), 3/4 Angus 1/4 Hereford (3A1H), and 1/2 Tarentaise 1/4 Angus 1/4 Hereford (2T1A1H) crossbred beef calves out of 347 cows were collected over the ten year period of 1976 to 1985. Calves were weighed at 30 to 45 day intervals from birth to weaning. All pairs were grazed on foothill grassland rangeland of southwestern Montana over a 10 year period of consistent range management practices. The objective of this study was to determine dam age, sex of calf, date of birth, year and calf breed effects on growth patterns of suckling calves. Calf gains were analyzed by least squares procedures, The statistical model included cow age, year, calf date of birth, sex of calf, breed of dam, breed of sire, and breed of calf.

Initial analyses indicated significant differences in calf growth response and pattern as a function of cow age. Sex of calf was a significant ($P<.001$) source of variation over all gain periods. Male calves gained .05 kg/d more over the total grazing season. Female calves gained .12 kg/d more than male calves in period 2. A significant ($P<.05$) negative regression of day of birth on calf average daily gain (ADG) was observed in periods 2 and 3. Significant ($P<.05$) regressions were observed in periods 2, 3 and 4. Year affected ($P<.001$) calf growth over each of the gain periods. Age of dam was an important ($P<.01$) source of variation in all periods except period 2. Calves from all cow age groups exhibited a decrease in ADG from period 3 to weaning. Breed of dam had a significant effect on calf growth in periods 3, 4, 5, and 7. Breed of sire was not an important ($P>.05$) source of variation on calf growth.

However, breed of dam and breed of sire interaction had a significant ($P<.05$) effect on calf growth in periods 1, 6, and 7.

Age related differences in milk production and nutritional requirements may explain the significance of dam age upon calf growth. Stress of castration could have directly affected the gain performance of steer calves in period 2. Decline of calf ADG from period 3 to period 6 could be attributed to numerous factors including: 1) decline in milk production of the dam; 2) decrease in forage quality and quantity; and 3) inexperienced grazing by the calf to meet nutritional requirements.

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I would like to dedicate this manuscript to my parents, Robert and Francess Church, and family. They have always encouraged and supported me throughout my life.

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ABSTRACT

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Initial analyses indicated significant differences in calf growth response and pattern as a function of cow age. Sex of calf was a significant ($P<.001$) source of variation over all gain periods. Male calves gained .05 kg/d more over the total grazing season. Female calves gained .12 kg/d more than male calves in period 2. A significant ($P<.05$) negative regression of day of birth on calf average daily gain (ADG) was observed in periods 2 and 3. Significant ($P<.05$) regressions were observed in periods 2, 3 and 4. Year affected ($P<.001$) calf growth over each of the gain periods. Age of dam was an important ($P<.01$) source of variation in all periods except period 2. Calves from all cow age groups exhibited a decrease in ADG from period 3 to weaning. Breed of dam had a significant effect on calf growth in periods 3, 4, 5, and 7. Breed of sire was not an important ($P>.05$) source of variation on calf growth. However, breed of dam and breed of sire interaction had a significant ($P<.05$) effect on calf growth in periods 1, 6, and 7.

Age related differences in milk production and nutritional requirements may explain the significance of dam age upon calf growth. Stress of castration could have directly affected the gain performance of steer calves in period 2. Decline of calf ADG from period 3 to period 6 could be attributed to numerous factors including: 1) decline in milk production of the dam; 2) decrease in forage quality and quantity; and 3) inexperienced grazing by the calf to meet nutritional requirements.

INTRODUCTION

Preweaning calf growth is affected by numerous biological and management related factors. Well documented effects include calf sex (Thrift et al. 1972), age (Minyard and Dinkel 1960), dam age (Nelsen 1976), milk production (Casebolt et al. 1983), and genetic sources of calf breed (Sharma et al. 1982). This calf growth has been observed from birth to weaning mainly in herds with a high degree of management. However, few data exist on calf growth in herds under less intensively managed breeding programs. Furthermore, average daily gain (ADG) may fluctuate from birth to weaning at distinct periods due to normal transformation in calf digestive physiology. Forage has been estimated to account for 20% of the gain during early grazing season and increasing to 50% later (Sims et al 1975). Calves may become functional ruminants as early as 70-100 days when adequate forage is present (Ansotegui 1986). Decline in range forage nutrients combined with the calf's increased dependence upon non-milk resources for growth could lead to periods of inconsistent gains. This would suggest alterations in management to optimize calf growth throughout the grazing season.

This study is part of ongoing range research at the Red Bluff Research Ranch. Our objective was to evaluate sources of variation in growth of suckling range beef calves for successive 30-50 d periods from birth to weaning. We hypothesized that under less-extensively managed production operations in the Northern Rockies maximum growth rates would be achieved for the period of 120 to 160-d-old (June - July) for spring-born calves. Subsequent growth rates would both diminish and exhibit greater variability as dietary reliance upon nutrient sparse range forages increased until weaning.

LITERATURE REVIEW

Effects Upon Calf Growth

Sex of Calf

Sex of calf has a significant affect on preweaning average daily gain (PWADG) in calves (Thrift et al. 1970). Tanner et al. (1970) in analyzing data from Angus calves found steer-heifer differences of .07, .04, and .03 kg/d PWADG for the years 1964, 1965, and 1966, respectively. Brinks et al. (1961) observed a .04 kg/d difference between steer and heifer calves raised on Hereford dams.

Kress and Webb (1972) analyzed PWADG and weaning weights of Angus and Hereford calves. Sex was a significant source of variation for PWADG and weaning weight in both breeds. Bull calf PWADG's (kg/d) were .09 and .07 greater than heifers for Angus and Hereford, respectively. A difference of 21.7 and 16.0 kg weaning weight existed between bull and heifer calves of Angus and Hereford, respectively. These results were in agreement with Koger and Knox (1945), Panish et al. (1961), Urick (1958), Bradley et al. (1965), and Linton et al. (1968).

In several studies multiplicative adjustments for sex differences have been calculated. Multiplicative adjustment factors adjust heifer and steer calves to a bull basis. Adjustment factors for Angus calves were calculated at 1.03 and 1.10 for steers and heifers (Anderson and Willham, 1978). Sellers et al. (1969) reported factors correcting to steer basis of 1.07 and 1.08 for Angus and Hereford heifers. Angus and Hereford bulls were corrected at .97 and .93 to steer basis. Cundiff (1966) reported Hereford adjustment factors of 1.02, 1.00, and .89 for heifer, steer and bull calves, respectively. Adjustment factors of 1.05, 1.00 and .95 for heifer, steer and bull calves were recommended by the United States Beef Cattle Records Committee Report (1965).

Knapp et al. (1980) analyzed preweaning and weaning data on 178 three-breed cross progeny of straight Hereford, Angus and Charolais heifers and contemporary reciprocal cross heifers. Sex of calf did not significantly affect differences in calf PWADG. They postulated that since cow ages were 2-3 years their lower milk production could have restricted sex differences in growth potential. Ahunu and Makarechian (1986) observed a difference of 3.1, 7.2, and 4.9% between steer and heifer calves of Hereford, Synthetic and crossbred dams, respectively.

Age of Calf

Age of calf has been found to be an important source of variation in preweaning calf growth. Urick (1985) found a difference of .072 kg/d between the earliest born calves and later born calves in a random-selected herd. A negative regression (-.0012) of date of birth on PWADG occurred indicating that earlier born calves had faster rates of gain. Nelms and Bogart (1956) analyzed data from 103 purebred Hereford and Angus pairs. A .09 kg/d higher PWADG occurred with calves born in the first part of the season over the mean PWADG. A difference of .17 kg/d higher PWADG existed between the early and late born calves. Neville (1962) observed that for each day later in the calving season that birth occurred calves weighed a significant .14 kg less at 4 months of age. Differences were non-significant by 8 months of age.

Minyard and Dinkel (1960) pooled weaning data of 2351 cow-calf pairs. The linear regression of weight on age within ranch-year-month subclasses was .54 kg. This value was somewhat smaller than Koger and Knox (1945) .60 kg and Botkin and Whatley (1954) .65 kg. Kress and Burfening (1972) found a negative regression (-.10) of 180 day weight on birth weight. Ahunu and Makarechian (1986) documented a significant age of calf effect on both weaning weight and PWADG on three biological types of beef cattle.

Nevins (1986) collected data on 169 cow-calf pairs over a two year span at the Red Bluff Research Ranch, Norris, MT. Date of birth was a significant source of variation in weaning weight. The partial regression coefficient was .43

kg/d. Each 1 day increase in day of birth caused a .43 kg decrease in weaning weight.

Range Forage

It has been estimated that by the time a calf reaches three months of age, non-milk resources account for more than one-half of the calf's energy intake (Maddox, 1965). Roy (1958) concluded that calves can be entirely dependent on good quality grass and gain .59 kg/d by eight weeks of age on forage.

Ansotegui (1986) analyzed intake and growth data on the Red Bluff research herd. Estimates of organic matter intake (g/kg body weight) indicate that calves may become self-sufficient at an early age (70-100 d) when adequate forage is available. From the findings it was concluded that calves become forage grazers and active ruminants at a very early age (<45 d) and possess many similarities to mature ruminants with regard to organic matter intake (g/kg body weight) and digesta kinetics.

Sims et al. (1975) studied cow-calf pairs on high plains grassland. It was estimated energy from forage accounted for approximately 20% of the gain made early in the grazing season with the contribution increasing to approximately 50% late in the grazing season.

Holloway et al. (1982) analyzed data of 153 Angus calves suckling cows on high quality (fescue-legume) and low quality (fescue) pasture over a four year period. Calves on high quality pasture gained .78 kg/d versus .70 kg/d for low quality pasture calves. Forage digestible energy intake (Mcal/kg dry matter) was 4.64 greater in the high quality pasture calves. The fescue pasture calves tended to rely more on the dams milk for gain than the fescue-legume calves.

Burns et al. (1972) studied gains in Angus calves grazing four levels of quality. Calves grazing the highest quality pasture gained 30 kg more than the lowest quality pasture calves in year 1 and 26.9 kg in year 2. Holloway et al. (1979) observed an 18 kg advantage for calves grazing high quality pasture over low quality.

Peichal (1980) analyzed range forage intake data on 78 Polled Hereford calves over a two year period. Range forage dry matter intakes (kg/d) for calves were 1.6, 2.4, 4.4, and 4.0 at 67, 97, 128, and 159 days of age, respectively. No forage dry matter intake data were recorded prior to day 67. Calf ADG were calculated for April, May, June, July, August, and September. ADG (kg/d) were .65, .80, .76, .66, .95, and .69, respectively.

Boggs et al. (1980) studied milk consumption affects on forage consumption in 2 to 6 month old Polled Hereford calves. Increased milk intake had a negative effect on grass intake by calves 2 to 6 months old. Two and six month old calves consumed .03 and .07 kg/d less grass for each kg of milk. These findings were similar to Lusby et al. (1976)

and Wyatt et al. (1977). Ansotegui (1986) observed during July calves consumed .3 kg more forage for each kg reduction in fluid milk intake. In both August and September, calves consumed .6 kg more forage for each kg decline in fluid milk intake.

Boggs et al. (1980) collected milk intake, forage intake and ADG of Polled Hereford calves. During the first two months, grass intake and ADG were negatively correlated. An increase in forage intake, day 60 to 150 of the grazing season, tended to improve ADG. During that time, each additional kg of grass consumed per day yielded about .02 kg/d more gain. The monthly dry matter intakes represented .62, 1.46, 1.51, 1.75, and 2.20% of the calves body weight for the months of May, June, July, August, and September, respectively.

Peichal (1980) reported range dry matter intakes of 1.6, 2.1, 3.0, and 2.4% of the calf's body weight for the months of June, July, August, and September. The calves weaning weight was positively affected by the average range dry matter intakes during the grazing season. Ansotegui (1986) observed average intake (kg/d) of crossbred calves were 1.00, 1.95, and 2.43 for the months of July, August, and September, respectively.

Langlands (1972) considered lower milk intake of Merino ewe lambs to be of secondary importance. As high voluntary intakes compensated for lack of milk if adequate forage was available.

Age of Dam

The most important source of variation in calf growth is age of dam (Marlowe and Gaines, 1958). Cunningham and Henderson (1965) reported calf PWADG improves with age of dam in a curvilinear relationship to a maximum at 7-10 years of age. Marlowe and Gaines (1958) found similar results where maximum production was attained at 6-10 years. These were in agreement with results by Brinks et al. (1962), Mahmud and Cobb (1963) and Brinks et al. (1972).

Nelsen and Kress (1981) analyzed registered cattle records of 5902 Angus and 5950 Hereford calves born in Montana over a 16 year period. Differences between age of dam classifications existed. Cows were grouped as 2, 3, 4, 5-10 and 11+ years of age for age of dam adjustments. Similar results were reported by Minyard and Dinkel (1960), Berg (1961), Warren et al. (1965), Sellers et al. (1969), and Anderson and Willham (1978).

Sharma et al. (1982) found little information exists on age of dam effects in multibreed or synthetic populations. Ahunu and Makarechian (1986) analyzed data of 2856 calf records for Hereford, beef crossbred and beef synthetic calves raised in Alberta, Canada. Weaning weight increased with increasing age of dam from 2 to 4 years in the Hereford and crossbred reaching its peak in calves of 5-yr-old dams.

The beef synthetic calves weaning weight increased from 2 to 6-yr-old dams. Sharma et al. (1982) compared Hereford and synthetic observing significant increases in the mean values of weaning weight and PWADG in calves of 5 to 6-yr-old dams in the synthetic breed, however, differences were not significant for Herefords. Ahunu and Makarechian (1986) found PWADG for calves of Hereford and crossbred cows began to decline in the 9+ age of dam category, but no apparent decline was noticeable in the synthetic population.

Nelms and Bogart (1956) analyzed Hereford and Angus calf growth data. Deviations from the herd mean PWADG (kg/d) were -.083, -.004, -.008, .018, and .077 for calves of 2, 3, 4, 5-7, and 8+ year old dams. A large difference between calves of 2-yr-old dams and those of older cows existed. However, the effect of age of dam on PWADG during the suckling period only approached significance. Similar results were reported by Tanner et al. (1970). Bogart (1956) reported a difference existed between 2-yr-old dams and mature cows.

Urick et al. (1985) collected data on 431 Hereford bull calves from a random-selected cow herd. A larger weaning weight difference existed between calves of 2-yr-old and older dams (34.5 kg) than reported in most other studies (Minyard and Dinkel 1960, Sellers et al. 1969, Anderson and Willham 1978, and Nelsen and Kress 1981). Inter study differences can probably by attributed to: (1) random selection, where smallest heifers are allowed to raise calves versus selected herds in which small heifers are generally not used; and (2) differences in nutrient availability from range forages in respective study areas may be inadequate for the 2-yr-old heifers (Houston and Woodward 1966; Houston and Urick 1972).

Nelsen and Kress (1981) concluded that correction factors for age of dam in the populations studied were 11, 6, 2, and 1% for Angus aged 2, 3, 4, and 11+, respectively., and 13, 8, 4, and 4% for Hereford dams aged 2, 3, 4, and 11+ years, respectively. Kress and Burfening (1972) reported adjustments of 18, 10, 5, and 2% for 2, 3, 4, and 11+ year old Hereford dams, respectively. B.I.F. (1986) maintains an additive adjustment corrected for age of dam and sex of calf. Adjustments (kg) are 27.2, 18.2, 9.1, and 9.1 for 2, 3, 4, and 11+ year old dams raising male calves and 24.5, 16.3, 8.2, and 8.2 for dams aged 2, 3, 4, and 11+ years raising female calves.

Dam Milk Production

Differences in level of milk production can account for up to 66% of the variance in weaning weight of beef calves (Neville et al. 1974). Rutledge et al. (1971) reported variation in weaning weight due to age of dam was expressed primarily through differential milk production of the age groups.

Klett et al. (1965) collected milk production and calf gain data on 15 Angus and 15 Hereford cow-calf pairs. Milk yield increased with increasing age of dam. Lactation curves followed the plane of nutrition, as nutrient level increased, milk yield also increased. Correlations of milk yield and calf gains were found in the Angus group in excess of .66. Small non-significant correlations were found in the Hereford group.

Rutledge et al. (1971) analyzed calf growth and milk yield data on 279 Hereford cow-calf pairs. Dams nursing female calves produced a significant 1.15 kg more milk than those nursing male calves. In contrast, Christian et al. (1965) and Melton et al. (1967) found no significant differences in milk yield attributable to sex of calf while Pope et al. (1968) reported higher milk production for cows nursing male calves. Milk yield increased with increasing age of dam up to 8.4 years. Approximately 60% of the variation in 205 day weight was due to variation of milk yield.

Kress and Anderson (1974) collected milk production data on 89 Hereford cows. The calculated range in total milk production for a 205 day lactation period was 420 to 1432 kg. The correlation with calf weight at the same stage of lactation was .49. A correlation of .59 was observed for calf weight at the next stage of lactation. Correlations for calf weight and milk production indicated that the relationship with immediately preceeding or succeeding milk production estimates was about .50. Relationships with milk production estimates more remote were smaller (e.g. 0.06). It was suggested that high milk producing cows at the start of lactation are not necessarily high producers at the end of lactation. Maximum milk production (7.3 kg/d) occurred at day 20 of the lactation and decreased to 0 at day 195 of the lactation.

Casebolt et al. (1983) analyzed data on 549 milk yield observations collected from 76 cows of five breed groups, Hereford, Angus-Hereford, 25% Simmental - 75% Hereford, Simmental-Hereford, and 75% Simmental - 25% Hereford dams. Hereford dams produced 2.3 kg/d less milk than the crossbred dams. Relative importance of milk production in reference to calf growth traits prior to weaning was shown by the correlation of .49 between average milk production and weaning weight and a .49 correlation between average milk production and calf PWADG. Early growth of the calf is highly dependent on the maternal ability of the dam to produce milk. The degree of crossbreeding of the dam can influence level of milk production and lactation curves.

Melton et al. (1967) collected milk production and calf growth data on 15 Angus, 15 Charolais and 15 Hereford dams. Cows nursing bull calves gave .58 kg/d more milk than those nursing heifers calves during the first 77 days of lactation. The sex differences diminished during lactation to

.10 kg/d during the last period and was not found to be a significant difference. Age of dam differences for total milk yield were 553, 667, and 809 kg for 2, 3-4, and 5+ years of age. Correlation coefficients between average daily milk yield and PWADG were .58, .38, .01, .19, .27, and .03 for day 1-77, 78-107, 108-137, 138-167, 168-196, and 197-224 of lactation. A declining relationship existed between milk production and PWADG as lactation progressed.

Wyatt et al. (1977) analyzed milk production data of 41 Hereford and 41 Fresian cows, exposing calves of two biological types to a low (Hereford) or high (Fresian) level of milk. Range Angus-Hereford calves on high milk consumed 5.5 kg more milk daily and were 47 kg heavier at weaning than calves on low milk. Drylot Angus-Hereford calves on the high milk level consumed 4.6 kg more milk daily and were 44 kg heavier at weaning than calves on low milk. Range and drylot Charolais and Fresian calves on high milk consumed 5.3 and 5.0 kg more milk and weighed 58 and 53 kg heavier at weaning than those on low milk. At high level the Angus-Hereford and Charolais-Fresian consumed 10.4 vs. 10.2 kg of milk. It appeared that the potential growth rate of calves had little affect on milk intake. At low milk intake an advantage in growth rate of larger Charolais-Fresian calves was .06 kg/d on range and .02 kg/d on drylot. High milk production had a negative effect on forage intake by calves in all groups except Charolais-Fresian in the August period.

MATERIALS AND METHODS

Study Site Description

The data for this study were collected at the Red Bluff Research Ranch operated by the Montana Agricultural Experiment Station, Montana State University. The ranch is located 56 km west of Bozeman, Montana on the Northwest slope of the Madison Mountain Range. The ranch covers a land area of 5200 ha with approximately 350 animal units (range cows and ewes). Elevations of the pastures range from 1400 to 2000 m with long, slight to moderate slopes and areas of steep slopes. Average annual precipitation ranges from 350 mm to 406 mm, (USDA-SCS 1976). Up to 40% of the precipitation falls during the months of May and June. The period of minimal moisture accumulation occurs from November to February (NOAA, 1982). The frost-free period ranges from 75 to 100 days.

In 1980, the Soil Conservation Service classified the range as being dominated by silty range sites in high-fair to good condition. Grasses and grass-like plants comprise fifty to ninety percent of the native range. Major grasses include: Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (Agropyron spicatum), and needle-and-thread (Stipa comata), (Turner 1985).

Experimental Animals

The cow herd consisted of approximately 130 crossbred beef cows. Breed composition of the cows were primarily Angus x Hereford (AH), 3/4 Angus 1/4 Hereford (3A1H), and 2/4 Tarentaise 1/4 Angus 1/4 Hereford (2T1A1H). A total of five straightbred Hereford, two Shorthorn cross and two Polled Hereford cross cows were eliminated from the data set. Calf records were collected on 347 individual cows which made up the data set. The original base herd consisted of Angus x Hereford (AH) and Hereford (HH) cows. The cows originated from Montana locations at Red Bluff Ranch Northern Agricultural Experiment Station at Havre, and the USDA Ft. Keogh Livestock and Range Research Station, Miles City. The cow herd was predominately middle-aged (5-10 years) up to 1980.

Growth data from 1014 crossbred beef calves were recorded over the ten year period of 1976-1985. All calves were raised on their natural dams under the same range environment. Bull calves from 1976-1983 and 1985 were surgically castrated on the date of the first weight. In 1984, bull calves were not castrated until weaning. These calves were adjusted to steer basis (weight x .95) (United States Beef Cattle Records Committee Report 1965). These data consist of 491 female and 523 male calves. The male calves were implanted with growth hormones in 1984 and 1985.

Calves were weighed five times over the grazing season (Table 1). Each year all calves were weighed on the same day, and weigh dates were consistent from year to year, using an electronic digital display scale. Calves less than 15 days of age at weigh period 1 were eliminated from the study. Young calves exhibited extreme variation in average daily gain (ADG) from -.05 to 7.36 kg/d. In 1976 and 1977 no calf weights were recorded on August 2. Period 5 was created to include these calves in the study for summer ADG analysis.

Table 1. Calf weigh periods.

Period	Begin Date	Weigh Date	Julian	Observations
1	Birth	May 13	132	981
2	May 14	June 15	163	979
3	June 15	August 2	210	791
4	August 2	September 9	251	791
5	June 15	September 9	251	981
6	September 9	October 12	284	981
7	Birth	October 12	284	981

The sire breeds of calves are reported in Table 2. The sire breed "other" includes all calves without specific sire documentation. Calves of these sires were eliminated from breed interaction analyses.

Table 2. Sire breeds number of progeny.

Sire Code	Breed	Progeny
1	Angus	569
2	Hereford	156
3	Tarentaise	155
9	Other	102

Management

The ranch is managed as a straight range commercial cow/calf operation. It can be classified as a "less intensively managed unit". All cow age groups are managed as one unit, grazing range forage with minimal supplemental feed, with selection/culling based upon pregnancy status and physical soundness. Calf growth performance records were not used to select replacements from the calves. The herd can be classified as basically a non-selected herd. Therefore, no direct genetic bias should occur with the older cows.

Natural service breeding was utilized exclusively from 1975-1978. In 1979, an artificial insemination program was implemented with natural service used for clean-up. All bulls were pulled from the breeding pastures by August 2. The average calving season was 63 days. No record of bull selection criteria was kept. Hereford bulls were utilized from the Northern Agricultural Research Station, Havre, MT., for a progeny test in 1984 and 1985.

Statistical Analysis

Least squares analysis of variance was conducted using Statistical Analysis Systems (SAS, 1985) General Linear Model procedure. The dependent variables were calf ADG during periods 1, 2, 3, 4, 5, 6, and 7. The independent variables included year, sex of calf, age of dam, breed of dam, breed of sire, and breed of dam breed of sire interaction. Calf day of birth was included in the model as a linear covariate.

RESULTS

Least squares analysis of variance for calf growth is presented in Table 3. Year, sex of calf, age of dam, breed of dam and breed of dam breed of sire interactions were important sources of variation.

Table 3. Least squares analysis of variance for calf growth (kg/d).

Source	df	Birth - May 13 MS	May 14 - June 15 MS	June 16 - Aug 2 MS	Aug 3 - Sept 9 MS
Year	8	12.32***	37.62***	9.91***	2.53***
Sex	1	.66***	3.56***	3.96***	.74***
Age of Dam	4	1.41***	.68	1.21***	1.44***
Breed of Dam(BR)	3	.13	.08	.31*	.31*
Sire Breed(SB)	3	.01	.26	.06	.11
BR * SB	8	.81***	.36	.39	.24
Birth Date	1	.035	.35*	.45***	.15*
R^2		.496	.418	.49	.32

Source	df	June 16 - Sept 9 MS	Sept 9 - Oct 12 MS	Birth - Oct 12 MS
Year	8	5.87***	19.73***	1.22***
Sex	1	2.92***	.63**	.61***
Age of Dam	4	1.32***	.90**	1.07***
Breed of Dam	3	.31**	.19	.12**
Sire Breed	3	.07	.13	.07
BR * SB	8	.29	.84*	.16*
Birth Date	1	.03	.02	.002
R^2		.53	.52	.445

* P<.05
** P<.01
*** P<.001

Sex of Calf

Sex of calf was an important source of variation over all seven gain periods. Least squares means are listed in Table 4.

Table 4. Least squares means of calf sex effect on calf growth (kg/d).

Sex	1 x	1 SE	2 x	2 SE	3 x	3 SE	4 x	4 SE
Female	.69	.02	.88	.03	1.04	.02	.92	.02
Male	.74	.02	.76	.03	1.18	.02	.98	.02

Sex	5 x	5 SE	6 x	6 SE	7 x	7 SE
Female	.98	.01	.76	.03	.86	.01
Male	1.09	.01	.81	.03	.91	.01

Male calves gained .05, .14, .06, .11, .05, and.05 kg/d more than female calves in periods 1, 3, 4, 5, 6, and 7, respectively. Female calves gained .12 kg/d more than male calves in period 2. PWADG of male calves was 6% more than female calves from birth to weaning.

Date of Birth

Date of birth is a significant source of variation in growth periods 2, 3, and 4. Regression values are shown in Table 5. Negative regressions of day of birth on calf ADG were found in periods 1, 2, 3, and 5. Calf ADG decreased

.0017 and .0022 kg/d with each additional day increase of birth day in periods 2 and 3. Negative partial regression coefficients in periods 1 and 5 were .0005. These small values lacked significance. In period 4, for each increase in day of birth calf ADG increased by .0013 kg/d. This was the only significant positive regression found. As gain period progressed past period 4, regression values of calf gain on date of birth were small and nonsignificant.

Table 5. Regression values of calf gain (kg/d) on day of birth over seven periods in the grazing season.

Regression	Period 1 b	Period 1 SE	Period 2 b	Period 2 SE	Period 3 b	Period 3 SE
Day of Birth (kg/d)	-.0005	.0004	-.0017*	.0008	-.0022**	.0006

Regression	Period 4 b	Period 4 SE	Period 5 b	Period 5 SE	Period 6 b	Period 6 SE
Day of Birth (kg/d)	.0013*	.0006	-.0005	.0004	.0004	.0006

Regression	Period 7 b	Period 7 SE
Day of Birth (kg/d)	.0001	.0003

* P<.05
** P<.01

Year

Least squares means for year effect on calf growth are presented in Table 6.

Table 6. Least squares means of year effect on calf growth (kg/d).

	Period							
	1		2		3		4	
Year	x	SE	x	SE	x	SE	x	SE
76	.55	.03	.81	.03				
77	.61	.03	.75	.06				
78	.71	.03	.81	.06	.94	.04	.94	.04
79	.52	.03	.86	.06	.97	.04	.73	.04
80	.60	.02	.91	.04	1.07	.03	.92	.02
81	1.01	.02	.64	.04	1.16	.02	1.02	.02
82	.70	.02	.91	.03	1.12	.02	.87	.02
84	.75	.02	.46	.03	1.45	.02	1.03	.02
85	.90	.02	1.25	.03	1.06	.02	1.05	.02

	Period					
	5		6		7	
Year	x	SE	x	SE	x	SE
76	.96	.03	1.01	.14	.86	.02
77	1.01	.03	.99	.05	.89	.02
78	.94	.03	.81	.04	.85	.02
79	.90	.03	.79	.05	.80	.02
80	1.02	.02	.69	.03	.87	.01
81	1.10	.02	.54	.03	.90	.01
82	1.00	.01	.51	.02	.85	.01
84	1.30	.01	1.07	.02	1.00	.01
85	1.05	.01	.65	.03	.92	.01

Year was a significant source of variation for all periods of the grazing season.

Age of Dam

Age of dam was an important source of variation on calf ADG in periods 1, 3, 4, 5, 6, and 7. Least squares means are listed in Table 7.

Table 7. Least squares means of age of dam effect on calf growth (kg/d).

Age of Dam	Period 1 x	SE	Period 2 x	SE	Period 3 x	SE	Period 4 x	SE
2	.54	.02	.74	.04	.96	.03	.81	.02
3	.70	.02	.80	.04	1.09	.02	.92	.02
4	.78	.02	.87	.01	1.17	.02	1.02	.02
5-9	.77	.02	.88	.03	1.17	.02	1.03	.02
10-14	.75	.03	.82	.06	1.14	.04	.98	.03
x	.71		.82		1.11		.95	

Age of Dam	Period 5 x	SE	Period 6 x	SE	Period 7 x	SE
2	.89	.02	.68	.03	.78	.01
3	1.00	.02	.78	.03	.86	.01
4	1.09	.02	.79	.03	.93	.01
5-9	1.11	.01	.86	.03	.95	.01
10-14	1.06	.03	.80	.05	.91	.02
x	1.03		.78		.88	

Calves nursing 5 to 9-yr-old dams gained .23, .07, -.01, and .02 kg/d more than calves of 2, 3, 4, and 10+ yr-old dams in period 1. In period 3, calves of 5 to 9-yr-old dams gained .21, .08, .00 and .03 kg/d more than calves of 2, 3, 4, and 10+ yr-old dams. In period 4, calves of 5 to 9-yr-old dams gained .22, .11, .01, and .05 kg/d more than calves of 2, 3, 4, and 10+ yr-old dams. In period 5, calves of 5 to 9-yr-old dams gained .22, .11, .02, and .05 kg/d more than calves of 2, 3, 4, and 10+ yr-old dams. In period 6, calves of 5 to 9-yr-old dams gained .18, .08, .07, and .06 kg/d more than calves of 2, 3, 4, and 10+ yr-old dams. Over the total grazing season calves of 5 to 9-yr-old dams gained .20, .09, .02, and .04 kg/d more than calves nursing 2, 3, 4, and 10+ yr-old dams.

Breed of Dam, Breed of Sire and Interactions

Breed of dam was a significant source of variation in periods 3, 4, 5 and 7. Least squares means are listed in Table 8.

Table 8. Least squares means of breed of dam effect on calf growth (kg/d).

	Period							
	1		2		3		4	
Breed	x	SE	x	SE	x	SE	x	SE
HxA	.73	.01	.83	.03	1.07	.02	.91	.02
3A1H	.68	.02	.80	.03	1.06	.02	.91	.02
2T1A1H	.71	.03	.83	.06	1.17	.04	1.03	.04

	Period					
	5		6		7	
Breed	x	SE	x	SE	x	SE
HxA	.99	.01	.75	.02	.85	.01
3A1H	.99	.01	.78	.02	.86	.01
2T1A1H	1.10	.03	.85	.05	.93	.02

In periods 1, 2, and 6 breed of dam had no effect on calf growth. Calves of 2T1A1H dams gained .10 and .11 kg/d more than calves of HxA and 3A1H during period 3. The 2T1A1H dams produced calves that gained .12 and .11 kg/d more than HxA and 3A1A1H calves in periods 4 and 5. Overall, calves of 2T1A1H dams gained .07 kg/d more than calves of HxA and 3A1H dams. Calves growth rates by breed of dam are presented in Figure 1.

Breed of sire was not a significant source of variation in calf growth. Least squares means are presented in Table 9.

Table 9. Least squares means of breed of sire effect on calf growth (kg/d).

	Period							
	1		2		3		4	
Sire	x	SE	x	SE	x	SE	x	SE
Angus	.70	.02	.83	.03	1.11	.02	.94	.02
Hereford	.71	.03	.75	.05	1.07	.03	.91	.03
Tarentaise	.71	.03	.85	.06	1.14	.04	1.00	.04

	Period					
	5		6		7	
	x	SE	x	SE	x	SE
Angus	1.02	.01	.82	.02	.89	.01
Hereford	1.00	.02	.76	.04	.85	.01
Tarentaise	1.07	.03	.76	.05	.91	.02

Breed of dam x breed of sire interaction was an important source of variation in calf growth in periods 1, 6, and 7. Least squares means are reported in Table 10.

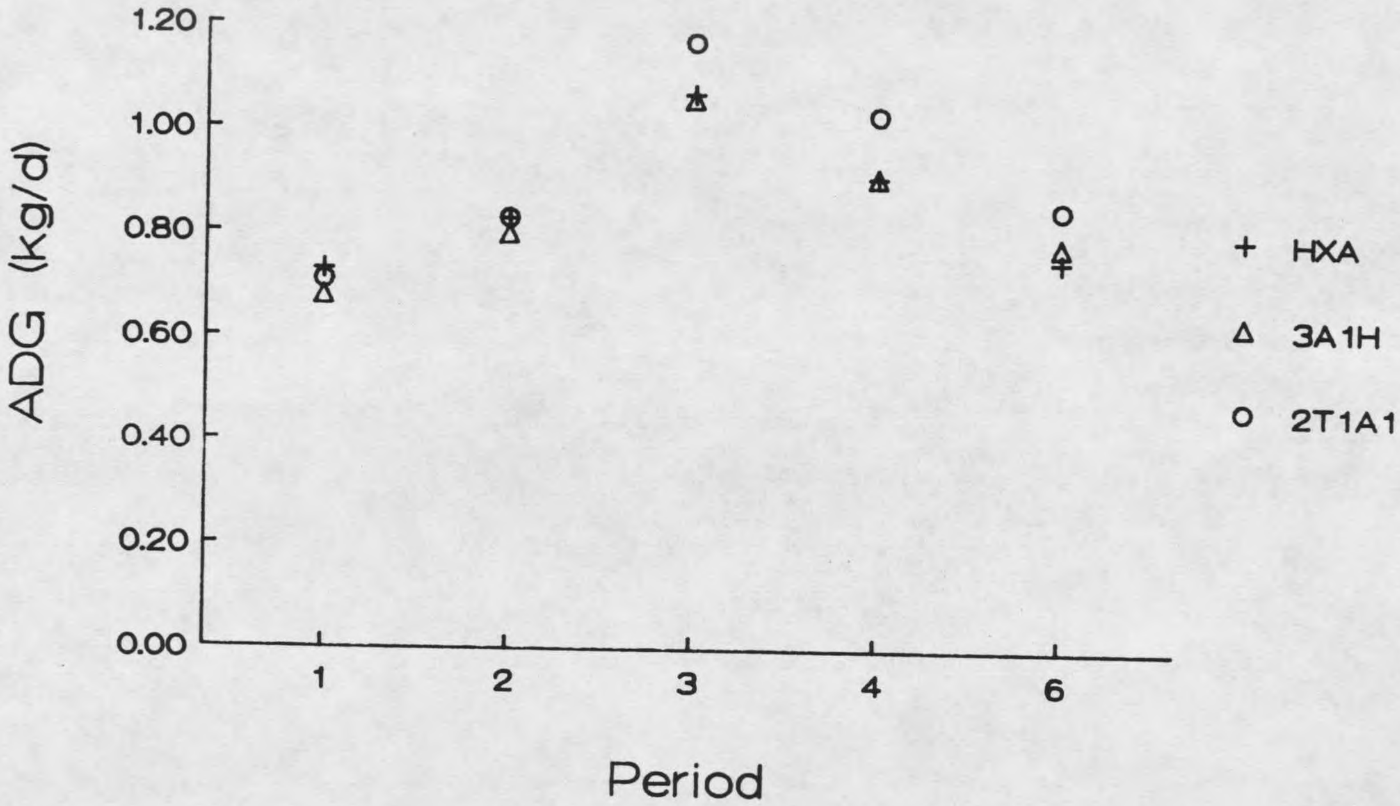

Figure 1. Average daily gains (ADG) of calves of Hereford X Angus (HXA), 3/4 Angus 1/4 Hereford (3A1H), and 2/4 Tarentaise 1/4 Angus 1/4 Hereford (2T1A1H) breeds of dams.

Calves of AxH dams and Angus sires gained .10 and .06 kg/d more than calves of Hereford and Tarentaise sires, respectively. Calves of 3A1H dams and Tarentaise sires gained .13 and .05 kg/d greater than calves of Angus and Hereford sires, respectively. Hereford sired calves of 2T1A1H dams gained .05 kg/d more than calves of Angus and Tarentaise sires.

Table 10. Least squares means of breed of dam and sire breed effect on calf growth (kg/d).

		Period					
		1		2		3	
Dam	Sire	x	SE	x	SE	x	SE
AxH	Angus	.78	.01	.87	.03	1.04	.02
	Hereford	.68	.03	.72	.06	1.05	.04
	Tarentaise	.72	.03	.89	.05	1.13	.03
3A1H	Angus	.64	.02	.76	.04	1.04	.02
	Hereford	.72	.02	.76	.04	1.06	.02
	Tarentaise	.77	.02	.84	.04	1.06	.02
2T1A1H	Angus	.68	.03	.85	.06	1.15	.04
	Hereford	.73	.03	.72	.06	1.21	.03
	Tarentaise	.68	.09	.89	.17	1.15	.11
		Period					
		4		5		6	
		x	SE	x	SE	x	SE
AxH	Angus	.89	.02	.96	.01	.73	.02
	Hereford	.93	.04	1.00	.03	.74	.05
	Tarentaise	.95	.03	1.04	.02	.79	.04
3A1H	Angus	.90	.02	.97	.02	.77	.03
	Hereford	.91	.02	.99	.02	.77	.03
	Tarentaise	.92	.02	.99	.02	.74	.03
2T1A1H	Angus	1.01	.03	1.08	.03	.92	.04
	Hereford	1.00	.03	1.12	.03	.94	.04
	Tarentaise	1.01	.10	1.08	.08	.88	.13
				Period			
				7			
				x	SE		
AxH	Angus			.86	.01		
	Hereford			.84	.02		
	Tarentaise			.90	.01		
3A1H	Angus			.83	.01		
	Hereford			.86	.01		
	Tarentaise			.88	.01		
2T1A1H	Angus			.92	.02		
	Hereford			.93	.02		
	Tarentaise			.92	.05		

DISCUSSION

Factors Affecting Calf Growth Patterns

Sex of calf had a large effect (P<.01) on calf growth. This observation agrees with other literature. Over the entire grazing season male calves gained faster than female calves. However, female calves gained more (.12 kg/d) during period 2 (May 13 to June 15, Figure 2).

Calf growth is influenced by genetic, maternal and environmental factors. The environment includes forage, terrain, weather and management. In these data the heifer advantage over steers in period 2 may possibly be attributed to management practices. Specifically, on the initial weigh day for period 2 (May 13) calves were branded, vaccinated and castrated. The stress of castration could have directly affected the gain performance of the steer calves. Castration was the only management difference between the steer and heifer calves. In 1984, bull calves were not castrated until weaning. The average gain for period 2 bull calves in 1984 was .07 kg/d greater than heifers. From this it may be inferred that castration may be an important factor on period 2 data.

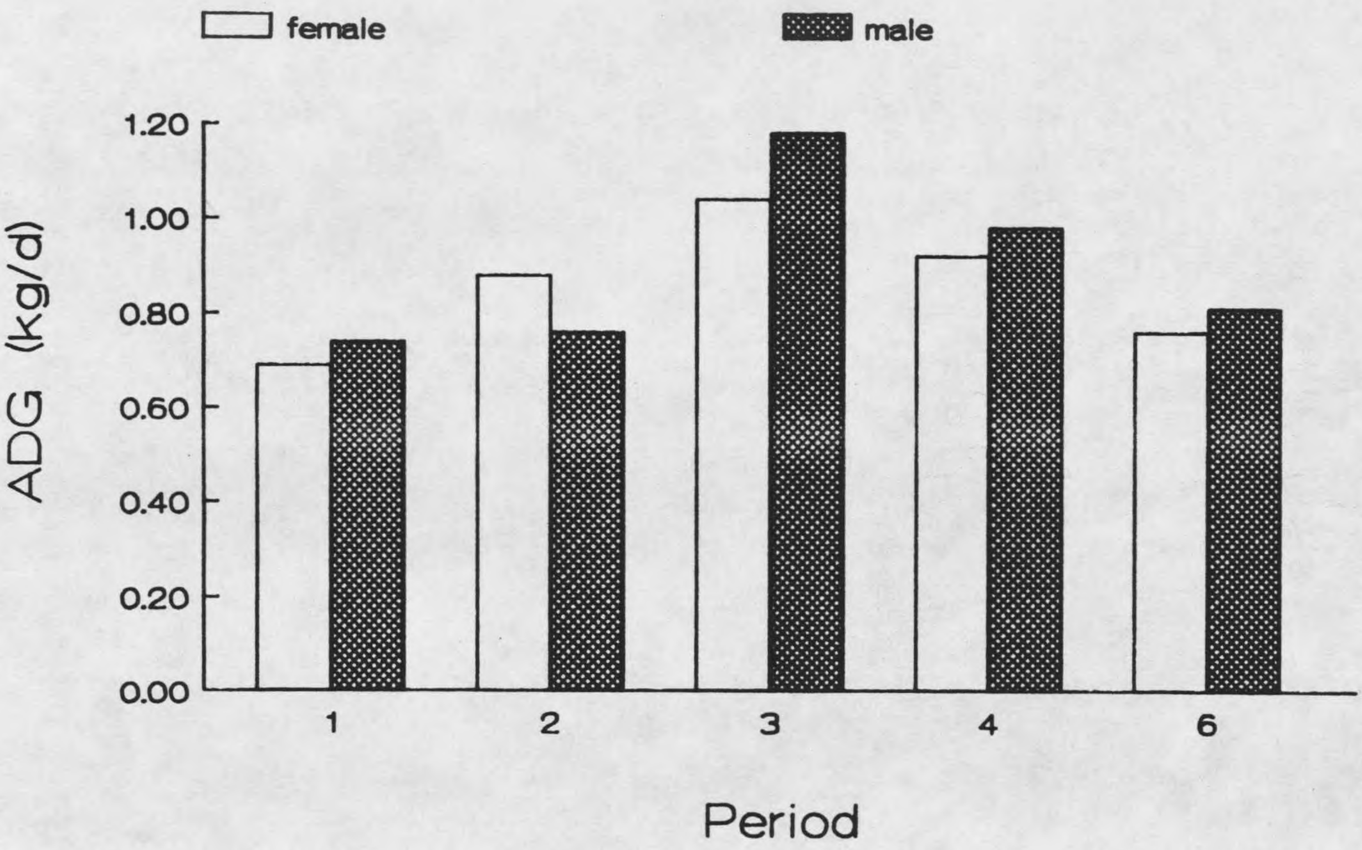

Figure 2. Female and male growth for period 1 (birth-May 13), 2 (May 13-June 15), 3 (June 15-August 2), 4 (August 2-September 9) and 6 (September 9-October 12).

Calf growth rate differed substantially over the grazing season periods. However, a consistent curvilinear relationship existed among the years. Calf ADG increased until period 3, then declined until weaning. The decline of ADG appears to begin at approximately day 130 of the calf's age. Casebolt (1983) reported the dam's milk production decreases to its lowest yield at approximately day 130 to 145 of lactation. Dry matter intake by calves has been reported to increase over the grazing season. This suggests that the calf is grazing to meet nutritional requirements not supplied due to lower milk production. If range forage is nutritionally inadequate, calves may not be able to consume enough forage to maintain performance during the decline in milk production of the dam. Ansotegui (1986) reported calves consumed a diet in relation to their intake that was higher in crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF), than that of the dam in the month of July. August diets of the calves were higher in NDF than cows. It was hypothesized that the calf's diet was attributed to it being an inexperienced and experimental grazer. Inexperienced grazing could be a factor affecting the calf's inability to achieve an adequate forage intake to maintain gain performance later in the grazing season. Robinson et al. (1978) suggested that in order to obtain good gains, calves must be provided with