Efficiency of Production in Cattle of Two Growth Potentials on Northern Great Plains Rangelands During Spring-Summer Grazing[1]

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ABSTRACT: A study was conducted to evaluate the effect of sire growth potential, steer age, and cow size on intake, growth, and production efficiency in grazing cattle. Data were collected on 24 cow-calf pairs during each of four summers (1989 to 1992) and on 12, 7-mo-old and 12 yearling steers during three summers (1990 to 1992). Suckling calves and older steers were sired by either high- (Charolais with high EPD for yearling weight) or moderate-growth-potential (Line 1 Hereford with average yearling weight ratios) bulls. Cow size was defined by principal component scores developed from cow weights, condition scores, and hip heights. Forage, but not milk, OM intake by suckling calves was influenced ($P < .05$) by sire growth potential. Yearling high-growth-potential steers tended to consume more OM than yearling moderate growth potential steers ($P < .10$) when expressed as kilograms/day but not when expressed as grams/kilogram BW ($P > .10$). Seven-month-old steers ate less ($P < .01$) forage (4.3 kg/d) than yearlings (5.6 kg/d) when expressed as kilograms/day but more ($P < .01$) when expressed as grams/kilogram BW (7-mo-old, 15.9 vs yearling, 14.4 g/kg BW). Cow OM intake was affected by cow size and milk production but not calf growth potential. Milk production but not cow size was a significant covariate for cow efficiency (grams of calf BW gain/kilogram of forage OM intake by cow-calf pair). Calf sire growth potential did not affect cow efficiency. We conclude that growth potential of sire for suckling calves and steers and cow size for cows affected intake of rangeland forage in summer but did not affect efficiency of production from Northern Great Plains rangelands.

Key Words: Beef Cattle, Efficiency, Intake, Grazing, Growth, Production

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J. Anim. Sci. 1996. 74:2317–2326

Introduction

Genetic selection and breed choice are two means used by the beef cattle industry to alter growth rate in cattle. The impact that increased growth rate may have on efficiency of production depends on the growth stage of the animal and the environment in which efficiency is measured. Cattle grazing on rangeland are subjected to a fluctuating environment with changes in nutrient quantity and quality throughout the year. This potentially limiting environment may affect the animal's ability to express genetic differences in growth potential and may, in turn, affect efficiency of production. Efficiency of beef production is reported to be related to breed (Marshall et al., 1976; Kress et al., 1990), animal size (Holloway and Butts, 1983; Kress et al., 1990), age (Coleman and Evans, 1986; Goetsch et al., 1991), and milk production (Neville, 1962; Rutledge et al., 1971; Clutter and Nielson, 1987). The objective of this study was to evaluate the impact that cow size, steer sire growth potential, and steer age have on growth, intake and production efficiency of cattle grazing northern Great Plains rangelands during the growing season.

Materials and Methods

A 4-yr study was conducted to evaluate intake and production of cow-steer calf pairs and fall-born and yearling steers of two growth potentials grazing native

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[1] This paper is a contribution from the USDA-ARS and the Montana Agric. Exp. Sta. Publication has been approved by the director of the Montana Agric. Exp. Sta. Journal Ser. J-4073 and No. 11381 from the Univ. of Nebraska Agric. Exp. Sta. Mention of a trade name or a specific proprietary product does not constitute a guarantee or warranty by the authors or USDA-ARS nor does it imply the approval of these products to the exclusion of others. USDA-ARS, Northern Plains ARS is an equal opportunity/affirmative action employer, and all agency services are available without discrimination.

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Received January 12, 1996.
Accepted June 3, 1996.

and improved pastures throughout the growing season in eastern Montana. The study was conducted at the Fort Keogh Livestock and Range Research Laboratory near Miles City, MT (46° 22′ N, 105° 52′ W). In the first year, 24 cow-steer calf pairs were used. In subsequent years, 24 cow-steer calf pairs, 12 yearling steers, and 12 fall-born steer calves (7-mo-old) were grazed together from mid-May to late September. Average birth date of calves was April 3. Beginning in May, all cattle were grazed in pastures of crested wheatgrass (*Agropyron cristatum*) for 2 wk. They were then moved to a 68-ha pasture that had been seeded with russian wildrye (*Psathrostachys juncea*) in 1977. Russian wildrye was approximately 30% of the herbage DM in 1991 and 1992. A June intake trial was conducted in this pasture. In July, cattle were moved to an 80-ha pasture of native range that had been contour-furrowed with a moldboard plow and interseeded with 'Ladak' alfalfa (*Medicago sativa*). Cattle grazed in this pasture until August, when they were moved to native rangeland. September samples were collected in a 265-ha pasture of native rangeland. Major forage species, in addition to introduced species mentioned previously, included western wheatgrass (*Pascopyrum smithii*), needle-and-thread (*Stipa comata*), blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), threadleaf sedge (*Carex filifolia*), Japanese brome (*Bromus japonicus*), and downy brome (*Bromus tectorum*).

Steers (suckling calves, 7 mo old, and yearlings) were of two genetic growth potentials. Those having high genetic potential for growth were progeny of Charolais sires selected for high yearling weight EPD in the Charolais national cattle evaluation. Contemporary steers having moderate genetic potential for growth were progeny of Line 1 Hereford sires with average yearling weight ratios. These sires were mated to multiparous crossbred beef cows with a wide variation in body size and milk production potential. Dams ranged from 3 to 11 yr of age. Cows were of varying proportions of Hereford, Charolais, Tarentaise, Angus, Red Angus, Simmental, and Shorthorn breeding. Two sires within each growth potential were used each year, with different sires used in different years. Breeding was done by artificial insemination, and sires were randomly assigned among cows. Suckling steer calves or their contemporaries with similar breeding and preweaning management became the subsequent year's yearling steers. Postweaning management of calves varied as steers were used to evaluate a variety of postweaning management schemes (Short et al., 1993, 1996; Grings et al., 1994).

Intake measurements were made on three occasions throughout the summer (early June, mid-July, and mid-September). On d 1 of each intake trial, cattle were weighed and given a sustained release chromic oxide bolus (Captec®, Nufarm, Auckland, New Zealand). During the June and July intake trials, suckling calves received a small sustained release chromic oxide bolus marketed for use in sheep (Grings et al., 1993). Cattle were held in corrals overnight without feed. Calves were separated from their dams at 1300 until 1900 when they were allowed to suckle the cow dry and then again separated from their dams. At 0700, 12-h milk production was estimated using weigh-suckle-weigh techniques (Knapp and Black, 1941). Cattle then grazed undisturbed until d 6 of this period.

On d 6, four yearling steers and eight suckling calves were fitted with fecal bags for a 6-d total collection of feces to provide a correction factor for release rate of chromic oxide from the bolus (Adams et al., 1991). Fecal bags were weighed, feces were subsampled, and bags were emptied each morning. On d 7 through d 11, cattle were gathered at 0700 each morning for collection of a fecal grab sample from the rectum.

Fecal samples were dried in a forced-air oven at 55°C until dry. Samples from d 7 through 10 were then composited on an equal dry weight basis. Samples from d 11 were kept separate and used to determine whether a bolus had been lost or malfunctioned during the week of sampling. Data on fecal output from 17% of fecal samples collected from cows, 7% from calves, and 8% from steers were not used due to extremely low or non-detectable Cr concentrations. Analysis on fecal samples included DM, ash (AOAC, 1990), and Cr (Williams et al., 1962). On d 14 of the period, cattle were again weighed, cow-calf pairs were held in corrals overnight, and milk production was again estimated using weigh-suckle-weigh. Milk production from the two estimates was averaged and multiplied by two to obtain daily milk intake. Fecal output contributed from milk was subtracted from total fecal output to obtain fecal output from forage for calves. Fecal output from milk was estimated from the assumptions that fluid milk was 12% solids and that milk solids were 92% digestible (Baker et al., 1976).

Six esophageally cannulated calves and five or six older cattle were used to evaluate diet quality. Older cattle were either 5-yr-old or older steers (1989, 1990), yearling steers (1990, 1991), or yearling heifers (1992). Differences in diet quality have been observed between calves and older cattle, but not between yearlings and older steers grazing these pastures (Grings et al., 1995). Cannulas were removed, and calves and steers were fitted with screen-bottom bags and allowed to graze for 30 to 45 min in the morning. In 1989 and 1990, a single collection was made at the time of fecal collections. In 1991 and 1992, collections were made 4 and 5 d before and 4 and 5 d after fecal collections. Samples were placed immediately on ice until return to the laboratory, where they were frozen, dried at 55°C (1989 and 1990) or lyophilized (1991 and 1992), ground, and analyzed for DM, ash, CP (Hach, 1987), NDF, ADL (Goering and Van Soest, 1970), ADF (AOAC, 1990), and in vitro OM digestibility (Tilley and Terry, 1963). Forage intake was estimated by dividing the fecal OM output attributed to forage by the diet indigestibility.

In 1991 and 1992, herbage mass and quality were determined at the time of the intake studies. During June and July, herbage mass was estimated using a multi-probe electronic capacitance meter (Neal et al., 1976) with 20% of the plots being clipped for calibration of the meter. September estimations were conducted by clipping 80 randomly located .25-m^2 quadrats. Samples were clipped to the ground, bagged, dried at 55°C for 48 h, and weighed for determination of herbage mass on a DM basis. After weighing, samples were composited by pasture and analyzed for DM, ash, CP, NDF, ADF, and ADL.

Cows were weighed and condition-scored (scale 1 = thinnest to 10 = fattest) at the beginning of the study, before the breeding season, after the breeding season, and at weaning. Condition scores were estimated by three persons and averaged. Hip heights were measured at the beginning of the study.

A principal component analysis (SAS, 1989) was conducted to reduce the number and colinearity of variables influencing cow size. Cow weights, condition scores, and hip heights were subjected to a general linear models procedure (GLM) to account for joint effects of year and cow age, with the residuals used in principal components analysis. The first (size1) and second (size2) principal component scores that resulted were used in further analysis.

Intake by suckling calves was analyzed in a model containing size1, size2, size1 × size2, milk OM intake, and calf birth date as covariates and sire growth potential, year, and month of sampling used as three main factors in the analysis. Intakes by 7-mo-old and yearling steers were analyzed in a single model that contained sire growth potential, age class, year, month of sampling, and all associated interactions. Organic matter intakes by cows were analyzed in a model that contained size1, size2, size1 × size2, milk production, and calf birth date as covariates. Discrete variables in the model included calf sire growth potential, year, month of sampling, and all associated interactions. Nonsignificant interactions were deleted from models as appropriate. Residual error terms were used to test model effects (Table 1). Orthogonal polynomials were used to evaluate month effects. Milk production and cow and calf forage intakes were averaged throughout a year and used to evaluate cow efficiency as defined by the weight of calf weaned per unit of forage OM intake by the cow-calf pair.

Results and Discussion

Study Environment. Precipitation patterns for the 4 yr during which the study was conducted are presented in Figure 1. Diet and herbage quality during the study period are presented in Table 2.

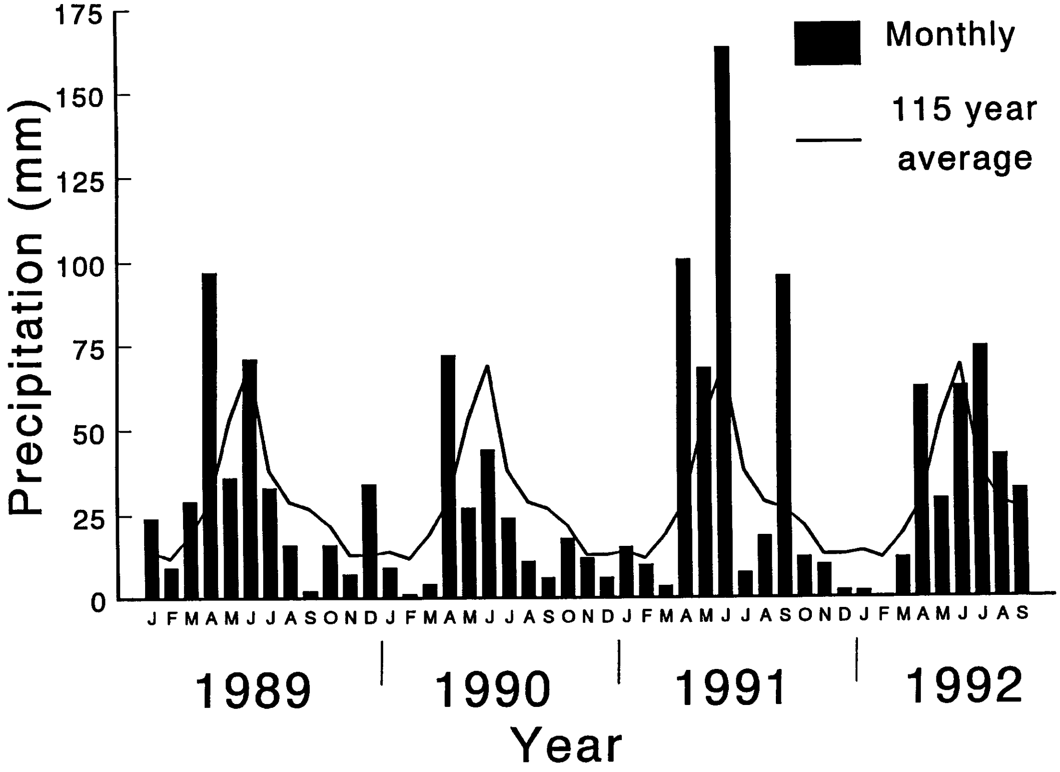

Figure 1. Average monthly precipitation at Miles City, MT from January 1989 through September 1992 compared with a 115-yr average.

Table 1. Analysis of variance for intake and weight of steers sired by bulls with different growth potential and intake and production efficiency of their crossbred dams grazing together on Northern Great Plains rangelands

		Cow		Calf						Steer			
		OM intake, kg/d		Initial weight, kg	Weaning weight, kg	Milk OM intake		Forage OM intake		OM intake		Initial weight, kg	Final weight, kg
Component	df		Eff.[a]			kg/d	g/kg BW	kg/d	g/kg BW	kg/d	g/kg BW		
		Mean Square											
Covariates													
Size1 (S1)[b]	1	62.1*	15.25	2.5	506.4	.226**	14.04*	.036	2.83	—	—	—	—
Size2 (S2)[b]	1	8.89	.06	1,010.1**	430.8	.672**	1.91	.422†	1.11	—	—	—	—
S1 x S2	1	14.33	5.48	83.0	7.9	.249*	13.80*	.006	4.65	—	—	—	—
Milk	1	68.79*	81.47*	—	34,470.6**	—	—	.966**	290.41**	—	—	—	—
Birthday	1	6.94	—	1,664.0**	3,123.4**	.280*	52.65**	.672*	3.31	—	—	—	—
Main effects													
Sire G.P.[c]	1	10.16	20.06	356.9†	3,452.8**	.035	21.88**	.779*	0.07	3.41†	13.12	14,513**	26,401**
Year	3	81.54**	58.66*	849.0**	959.9*	.058	3.66	.876**	14.13*	23.33**	57.78**	5,605*	9,849**
Month	2	81.42**	—	—	—	2.068**	841.10**	55.974**	542.94**	67.76**	204.36**	—	—
Year × month	6	51.31**	—	—	—	.072	4.64†	3.639**	95.41**	11.36**	89.66**	—	—
Sire G.P. × month	2	76.70**	—	—	—	—	—	—	—	—	—	—	—
Sire G.P. × year	3	—	1.72	150.7	1,501.2**	—	—	—	—	—	—	—	—
Age	1	—	—	—	—	—	—	—	—	85.85**	119.78**	211,801**	271,104**
Age × sire G.P.	1	—	—	—	—	—	—	—	—	.08	30.03†	4,326†	5,260†
Age × year	2	—	—	—	—	—	—	—	—	13.23**	106.63**	1,114	1,087
Forage intake		—	—	—	826.6	—	—	—	—	—	—	—	—
Error df		159	65	80	76	220	220	219	219	185	185	63	63
Error MS		14.68	15.59	101.3	354.3	.054	2.56	.135	5.15	1.08	8.45	1,416	1,596

[a] Eff. = cow efficiency, kg calf weight gain/kg forage intake by cow and calf.

[b] Size1 and size2 are principal component scores for cow size (see text).

[c] G.P. = growth potential.

*, **, †Significant at the .05, .01, and .10 levels, respectively.

Lactating Cows. Initial cow weights in this study ranged from 377 to 793 kg (average 544 kg). Initial condition scores ranged from 4 to 8 (average 5.4) and hip height ranged from 118 to 141 cm (average 130 cm). Cows averaged 567 kg at the end of the grazing season with an average condition score of 5.7. Milk production averaged 7.4 kg/d with a range in June of 2.8 to 14.6 and a range in September of 1.1 to 10.0 kg/d.

In the principal components analysis of residuals, correlations among weights and condition scores measured over time ranged from .87 to .94 and from .63 to .76, respectively. Correlations between weights and condition scores averaged .45, and correlations of weights and condition scores with hip height averaged .64 and .04, respectively.

Researchers evaluating the effect of cow size on production efficiency have used a variety of traits to describe cow size, including weight, height, and condition score (Kress et al., 1969; Lindsey et al. 1970; Marshall et al., 1976; Holloway and Butts, 1983). To reduce the number and colinearity of variables influencing cow size, a principal component analysis was conducted. This analysis provides a principal component score that is a linear combination of traits with the first principal component being that which provides the greatest discrimination among individuals. The first principal component in our analysis (size1) accounted for 61% of the collective variation in residual weights, condition score, and hip height and had positive loadings for all weights (.39), condition scores (.29), and hip height (.24). Thus, cows having large values for size1 were heavier with greater condition scores and hip height than cows with small values for size1. The second principal component (size2) accounted for 22% of the variation and had negative loadings for cow weights (−.21) and hip height (−.48) but positive loading for condition score (.37). Thus, cows having large values for size2 were lighter in weight and shorter in stature but had greater condition scores than cows with small values for size2. In both the first and second principal components, there was little within-trial variation to the loadings given to either weights or condition scores.

Organic matter intake by lactating cows was affected by the principal component (size1) of cow size that distinguished tall, heavy cows from short, thin cows (Table 1). Adams et al. (1987b) also reported that cows of large body size consumed more total forage but ate less per unit BW than cows of smaller body size. Milk production of cows also affected cow OM intake. Milk production had a much greater effect on OM intake for cows with a large score for size1 than cows with low or negative scores for size1 (Figure 2).

Cow OM intake throughout the summer varied quadratically ($P < .01$), increasing from June to July (Table 3). Milk production declined linearly throughout the same period, indicating that milk production was not the sole driving force affecting monthly changes in intake. Pastures grazed during July had been interseeded with alfalfa and alfalfa averaged about 11% of the standing crop DM in 1991 and 1992. Higher intakes have been observed in pastures containing grass-legume mixtures than grass alone (Holloway and Butts, 1983). Higher intake of legumes at a given level of digestibility is related to increased rates of digestion of the legume (Thornton and Minson, 1973).

Dams of high-growth-potential calves had lower OM intake in July (10.4 vs 13.2 kg/d) but greater OM intake (11.7 vs 9.9 kg/d) in September than dams of moderate-growth-potential calves. These differences were not reflected in milk production. When averaged across the entire grazing period, sire growth potential did not affect cow OM intake.

There were year × month interactions in cow OM intake (Tables 1 and 3) due to decreased intakes in June of 1991 and increased intakes in September of 1992. Year differences in OM intake ($P < .01$) for lactating cows were related to increased intakes in 1992 when OM intake averaged 12.6 kg/d compared with 9.5, 9.9, and 10.2 kg/d in 1989, 1990, and 1991, respectively. The increased intake in 1992 is not well explained by diet quality. Herbage mass was 921 kg/ha in September 1992 and 568 kg/ha in September 1991. Herbage mass was not estimated in other years.

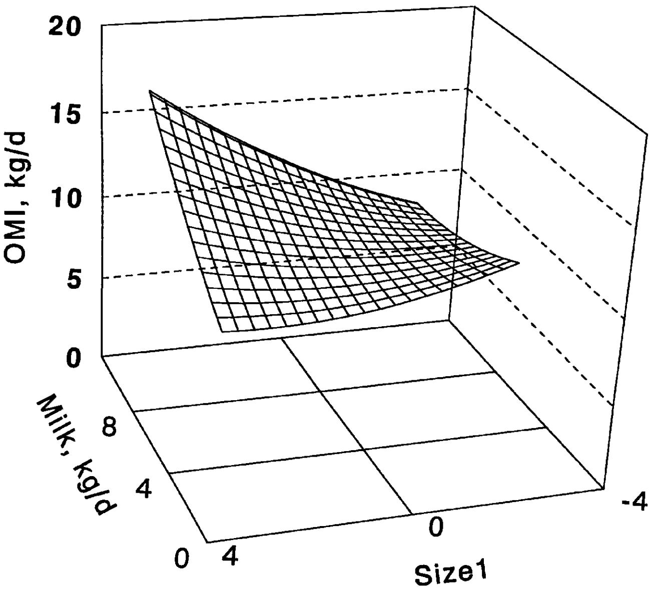

Figure 2. Relationship among milk production, size1 (principal component score describing cow size), and OM intake for crossbred beef cows grazing Northern Great Plains rangeland. The equation for this response surface is: $8.61967 - 1.244 \times (\text{size1}) + .0897 \times (\text{size1})^2 - .20988 \times (\text{milk production}) + .035947 \times (\text{milk production})^2 + .214915 \times (\text{size1} \times \text{milk production})$.

Table 2. Average diet quality during four years of the experiment and herbage quality in the last two years

Month and year	CP	NDF	ADF	ADL	IVOMD[a]
	Diet quality, % of OM				
June[b]					
1989	11.1	81.5	50.4	4.7	57.2
1990	14.1	84.7	49.9	7.2	60.1
1991	18.0	67.1	40.5	4.0	68.5
1992	10.5	73.2	42.4	4.8	62.7
July[c]					
1989	9.6	80.6	54.6	8.7	49.2
1990	9.4	77.3	48.8	8.2	58.2
1991	15.5	61.2	41.2	5.7	58.8
1992	12.1	64.2	41.3	6.6	59.3
September[d]					
1989	7.3	81.9	57.0	7.2	41.4
1990	7.9	79.8	52.5	7.2	44.7
1991	8.3	79.7	52.8	7.4	48.4
1992	8.2	86.5	56.6	8.5	55.4
	Herbage quality, % of OM				
June[b]					
1991	10.2	63.5	39.2	5.4	—
1992	10.3	64.4	34.9	3.9	—
July[c]					
1991	11.2	63.0	37.1	3.5	—
1992	6.9	71.3	42.9	5.1	—
September[d]					
1991	5.9	74.1	47.8	5.8	—
1992	5.0	74.9	45.8	5.2	—

[a] IVOMD = in vitro OM digestibility.
[b] Cattle were grazing rangeland seeded with Russian wildrye.
[c] Cattle were grazing native rangeland that had been contour furrowed and interseeded with alfalfa.
[d] Cattle were grazing native rangeland.

Herbage mass could potentially limit intake at these levels of DM production (Scarnecchia et al., 1985).

Cow efficiency (grams of calf BW gain/kilogram of forage OM intake by cow-calf pair) ranged from 77 in 1992, when high OM intake for both cows and calves resulted in a reduced efficiency, to 106 in 1989, when increased calf gain throughout the summer resulted in an improvement in efficiency (Table 4). Calf growth potential was not a significant factor affecting cow efficiency (Table 1) because high-growth-potential calves increased forage intake to meet their increased nutritional demands for growth.

The two principal components describing cow size were not significant covariates in the model describing cow efficiency. Holloway and Butts (1983) reported a size × nutritional environment interaction for cow efficiency. In their study, cows that were either structurally smaller or had small amounts of fatness were the most efficient when grazing fescue pastures; however, size was not a factor in efficiency when cows grazed fescue-legume pastures.

Milk production was a significant adjustment factor for cow efficiency ($P < .05$), and greater milk production was associated with greater efficiency. This agrees with the results of Marshall et al. (1976), who reported that cow size and condition had little effect on efficiency, whereas milk production had positive effects. These researchers found that larger cows produced enough increased calf weight to balance their greater nutritional demands under drylot and improved pasture conditions. Fredeen et al. (1981), however, reported that whereas milk production increased calf weaning weight per cow exposed at breeding under semi-intensive management conditions, under extensive range conditions reproductive

Table 3. Organic matter intake for crossbred beef cows throughout each summer, adjusted for cow size, milk production, and day of lactation[a,b]

Year	June	July	September
	OM intake, kg/d		
1989	8.7	10.0	9.7
1990	7.9	12.1	9.9
1991	6.2	13.6	10.9
1992	13.5	11.4	12.8
Average[c]	9.1	11.8	10.8

[a] Model $R^2 = .32$.
[b] See Table 2 for analysis of variance and levels of significance.
[c] Quadratic effect of month ($P < .01$).

Table 4. Efficiency of production (g calf BW gain/kg forage OM intake by cow-calf pair) of weaned calf from rangeland with steer calves sired by bulls of two growth potentials[a,b]

	Sire growth potential	
Year	High	Moderate
1989	111	101
1990	94	84
1991	98	96
1992	81	73
Average	96	87

[a] Model $R^2 = .23$.
[b] See Table 2 for analysis of variance and levels of significance.

efficiency was reduced. In previous research at this location (Adams et al., 1993), cows with high milk production did lose body weight during and after the breeding season but cows with low milk production maintained body weight; there was no difference in fall pregnancy rates among cows of different milk production potentials.

Suckling Calves. Suckling calves sired by high-growth-potential bulls gained more weight and were heavier at weaning (Tables 1 and 5) than those sired by moderate-growth-potential bulls during 1991 and 1992 but not 1989 or 1990. Differences among years may be due to the use of different bulls each year or to differences in diet quality among years (Table 2). Differences due to sire breed reflects not only breed differences between Hereford and Charolais-sired calves (Smith et al., 1976), but also the specific selection of high- and moderate-growth-potential sires from within these breeds. Weight differences due to growth potential could be slightly greater than in other reports because only male calves were used in this study (Smith et al., 1976; Nelson et al., 1982). When calf weight gains were analyzed separately for the first and second half of the grazing season, ADG averaged .99 kg/d for both periods. However, differences between growth potential groups were observed only in the first half of the season. From the start of the grazing period to the July intake trial, high-growth-potential calves gained .08 kg/d more ($P < .05$) than moderate-growth-potential calves. Decreased milk production, accompanied by declining diet quality, could account for the lack of difference between growth potential groups late in the season.

Table 5. Least squares means of intake and weight of steers sired by bulls of two growth potentials[a]

	Sire growth potential		
Age	High	Moderate	SEM
	Forage OM intake, kg/d		
Suckling calf[b]	1.2*	1.1	.02
7-mo-old	4.5	4.2	.11
Yearling	5.8	5.5	.10
	Forage OM intake, g/kg BW		
Suckling calf	6.9	6.8	.14
7-mo-old	16.1	15.8	.30
Yearling	13.8	15.0	.29
	Milk OM intake, kg/d		
Suckling calf	.86	.89	.02
	Milk OM intake, g/kg BW		
Suckling calf	6.3*	6.9	.10
	Initial weight, kg		
Suckling calf	74†	70	1.0
7-mo-old	226	213	4.7
Yearling	351**	307	3.8
	Final weight, kg		
Suckling calf			2.0
1989	231	224	
1990	210	215	
1991	240**	213	
1992	235**	206	
7-mo-old	308	289	5.0
Yearling	450	395	4.0

[a] See Table 2 for analysis of variance.
[b] Suckling calf intakes and weights are adjusted for cow size and day of birth.
*, **, †Means differ due to sire growth potential, $P < .05$, $P < .01$, and $P < .10$, respectively.

Table 6. Least squares means of milk and forage OM intake of suckling calves sired by bulls of two growth potentials adjusted for cow size and date of birth[a,b]

Year	June	July	September	Average
		Milk OM intake, kg/d		
1989	1.08	.84	.69	.87
1990	1.07	.96	.63	.88
1991	.94	.88	.69	.84
1992	1.03	.94	.77	.91
Average[c]	1.03	.91	.70	—
		Milk OM intake, g/kg BW		
1989	10.1	5.6	3.2	6.3
1990	11.0	6.4	3.1	6.9
1991	9.5	6.6	3.2	6.5
1992	9.8	6.7	3.7	6.8
Average[c]	10.1	6.3	3.3	—
		Forage OM intake, kg/d		
1989	.39	.92	2.02	1.11
1990	.33	1.12	1.78	1.07
1991	.46	.67	2.37	1.47
1992	.40	.58	3.07	1.35
Average[c]	.39	.82	2.31	—
		Forage OM intake, g/kg BW		
1989	3.9	6.3	8.3	6.2
1990	3.7	8.0	8.3	6.7
1991	5.1	5.3	10.8	7.1
1992	4.2	4.3	13.9	7.4
Average[c]	4.2	6.0	10.3	—

[a] Model R^2: Milk, kg/d, .37; milk, g/kg BW, .78; forage, kg/d .88; forage, g/kg BW, .70.
[b] See Table 2 for analysis of variance and levels of significance.
[c] Linear effect of month, $P < .01$; quadratic effect of month, $P < .01$.

Milk OM intake was a significant adjustment factor for calf weaning weights (Table 1), which is consistent with reports that weaning weight is positively related to milk production of the cow (Neville, 1962; Rutledge et al., 1971; Clutter and Nielson, 1987), including work at this location (Adams et al., 1993). Cow size was not a significant covariate in the model describing calf weaning weight in our study. Nelson et al. (1982) reported that although dam weight and weight change affected weight and ADG of calves sired by Angus or Charolais bulls, effects were minimal and did not alter the degree of difference due to sire breed. Holloway and Butts (1983) reported that weaning weight was related to the structural size and milk production of the cow when grazing fescue pastures, but not when grazing fescue-legume pastures.

Forage, but not milk, OM intake (kilograms/day) by suckling calves was influenced by sire growth potential (Tables 1 and 5). When forage intake was expressed per unit of BW, there was no effect ($P > .10$) of sire growth potential, indicating that the increased forage intake by high-growth-potential calves was related to increased BW. Milk OM intake was greater on a BW basis for moderate-growth-potential calves than for high-growth-potential calves. Dam milk production was not affected by calf sire genotype, so the smaller, moderate-growth-potential calves were provided more milk on a BW basis. Increases in calf weaning weight associated with sire growth potential were related to the increased forage OM intake exhibited by the high-growth-potential calves. The ability of suckling calves to increase forage intake to meet nutrient demands is reportedly dependent on forage quality (Holloway et al., 1982). However, in the present study there were no sire growth potential × month interactions (deleted from final model due to lack of significance) for forage OM intake, indicating that forage quality did not limit OM intake of high-growth-potential calves.

Milk and forage OM intake were affected ($P < .01$) by month of sampling (Tables 1 and 6) as was total OM intake (data not shown). Variation among months was expected due to increasing age of calf. Forage and total OM intake were affected by year, and there were year × month interactions. Year differences were due to increased intake in 1992. The increased average intakes for 1992 were due to greater intakes during the September period. This was similar to the response observed for lactating cows. Total OM intake for suckling calves averaged 2.0, 2.0, 2.0, and 2.3 kg/d for 1989 through 1992. Calf forage OM intake was lower than that reported by Bailey and Lawson (1981), who estimated the DM intake of Angus calves grazing shortgrass range in Alberta increased from .5 kg/d at 44-d of age to 5.5 kg/d at weaning (175 kg). Boggs et al. (1980) reported that forage DM intake

Table 7. Least squares means of intake of steers of two ages, 7 months old (7 mo) or yearling (Yrlg), during the summer grazing period[a,b]

	June		July		September	
Year	7 mo	Yrlg	7 mo	Yrlg	7 mo	Yrlg
	Forage OM intake, kg/d					
1990	2.9	3.8	5.45	6.2	5.7	5.4
1991	3.0	4.4	3.8	5.14	4.5	5.73
1992	3.7	5.6	4.0	6.1	5.8	8.65
Average[c]	3.2	4.68	4.34	5.89	5.43	6.54
	Forage OM intake, g/kg BW					
1990	12.0	10.70	19.9	15.90	19.76	13.4
1991	14.01	12.9	15.6	13.32	15.8	13.41
1992	14.1	15.37	14.1	15.3	18.2	19.26
Average[c]	13.4	13.04	16.1	14.81	17.9	15.20

[a] Model R^2: kg/d, .67; g/kg BW, .50.

[b] See Table 2 for analysis of variance and levels of significance.

[c] Linear effect of month, $P < .01$.

increased from .44 to 3.52 kg/d (.6 to 2.2% of BW) for Hereford calves between May and September. However, milk intake was greater in our study than in the former two. Suckling calves tend to compensate for decreased milk intake by increasing forage intake (Baker et al., 1976; Ansotegui et al., 1991).

Fall- and Spring-Born Steers. Weights of both 7-mo-old and yearling steers differed by sire growth potential (Tables 1 and 5). Average daily gain for 7-mo-old steers was .59 kg/d, compared with .86 kg/d for yearlings. The ADG for 7-mo-old steers is similar to the .61 kg/d reported for this age class of steers grazing similar rangelands (Grings et al., 1994). In previous studies with yearling steers, summer weight gains have ranged from .3 to .8 kg/d (Heitschmidt et al., 1993; Grings et al., 1994). The lower gain of 7-mo-old steers than of yearlings could be related to diet quality, because dietary protein concentrations were often below those required for maximum growth of animals of this age (NRC, 1984). Previous research at this location has shown that fall-born steers respond more consistently to protein supplementation during the summer grazing period than do yearling steers (Grings et al., 1994).

High-growth-potential steers tended ($P = .07$) to increase OM intake compared to moderate growth potential steers when expressed as kilograms/day but not when expressed as grams/kilogram BW (Tables 1 and 5). Overall, 7-mo-old steers ate less ($P < .01$) forage (4.3 kg/d) than yearlings (5.6 kg/d) when expressed as kilograms/day but more ($P < .01$) when expressed as grams/kilogram BW (7-mo-old, 15.9 vs yearling, 14.4 g/kg BW). Although this is similar to previous reports at this location (Grings et al., 1994) with British-cross cattle, it differs from the results of Coleman and Evans (1986), who found that spring-born steers (yearlings) consumed more per unit metabolic body size than did younger, fall-born steers when fed a growing ration in the drylot. Differences among studies could be related to diet quality or growth potential. There was a tendency ($P < .10$) for a sire growth potential × age class interaction for forage intake when expressed on a BW basis. Whereas moderate-growth-potential steers tended to consume similar amounts of OM per unit of BW regardless of age, high-growth-potential yearling steers tended to consume less OM per unit BW than 7-mo-old high-growth-potential steers.

Forage OM intake by steers increased linearly ($P < .05$) throughout the growing season (Table 7). This increase in forage OM intake was not related solely to increases in BW, because OM intake expressed as grams/kilogram BW also increased linearly ($P <.05$) throughout the growing season. Changes in gut fill may allow for changes in intake as forage quality declines (Funk et al., 1987). We have observed varied changes in intake throughout the growing season at this location. Adams et al. (1987a) and Ward et al. (1990) observed no change in intake throughout the growing season when steers grazed native range pastures. More recently, we observed increases in intake between early and late growing season (Grings et al., 1994); however, intake as a proportion of BW during June (Table 7) was less than the 19 to 20 g/kg BW reported for steers on native rangeland by Adams et al. (1987a) and Ward et al. (1990).

Implications

Growth potential of calf sire did not influence efficiency of production to weaning, even though weaning weight was greater for the high-growth-potential calves in some years. High-growth-potential calves consumed more forage to meet the nutritional demands for extra growth. Calf sire growth potential did not affect milk production or cow intake, so there were no extra nutritional demands placed on the cow rearing a high-growth-potential calf. Cow size did influence forage intake of cows but not efficiency of production. Efficiency of production did increase with increasing milk production. Sire growth potential did not influence growth rate of older steers during the summer grazing season. Suckling calves were able to express genetic differences for growth during the early part of the summer grazing season, whereas older steers were not.

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