MILK PRODUCTION IN RANGE BEEF COWS AND ITS RELATIONSHIP TO CALF GAINS

V. M. Gleddie[1] and R. T. Berg
Department of Animal Science, University of Alberta, Edmonton, Alberta

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ABSTRACT

Milk yield in lactating range beef cows was estimated by milking 42 cows four times at approximately monthly intervals during the lactation. Milking was by machine after oxytocin injection. Weights of calves, before and after suckling, over a 24-hour period were used to estimate calf consumption. Breed–age group averages for 24-hour milk yield varied from 3.7 to 8.4 kg, with an overall average of 6.4 kg. Breed of cow accounted for 82.5% of the variance in milk yield in these data. Milk yield declined on the average by 0.02 kg per day of lactation. The correlation between calf consumption and milk yield was 0.58. Butterfat was 3.9% on the average, protein 3.5%, solids-not-fat 9.1% and total solids 13.0%. Breed–age group or month of test did not significantly influence milk constituent percentages, although butterfat and total solids tended to rise as lactation progressed.

A good estimate of milk yield was obtained by one test milking. Milk composition based on one test milking was not reliable. Milk yield as estimated in any month was highly related to calf average daily gain from birth to weaning. Use of two test milkings improved the relationship only slightly. Milk solid component percentages showed little relationship to calf gains.

INTRODUCTION

Milk yield in beef cattle is important because of its influence on the growth of the nursing calf. A knowledge of milk production by beef cows might provide additional information which could be useful in improving calf weaning weights. An initial proposal for progeny testing of beef cattle included milk consumption as a measure of efficiency of feed utilization in the suckling period (20). Since that time, various measurements of milk yield of British beef breeds have been made (5, 8, 11, 12, 16) and in addition, there has been some testing of dairy–beef crossbred cows (6, 22).

The relationship of milk yield to calf gain has been reported by several groups of workers (4, 12, 22). Milk composition studies in beef cattle have not been extensive except for percent butterfat, and more information is needed on the relationship of milk composition to suckling calf gains.

The present experiment was conducted to study lactation trends for milk yield and composition and interrelationships of milk yield, milk composition, calf consumption and calf gains in single-suckled range beef cattle.

MATERIALS AND METHODS

Cows from the University of Alberta beef breeding herd were used for the present study. The breeding plan and general management of this herd have been described by Berg (3). Cows were selected for test milking from those which had calved in a 40-day period, and none had calved more than 45 days prior to the first test date. An attempt was made to sample different breeding and age groups of cows, and the sexes of the calves were balanced. The experimental group consisted of eight each of mature Hereford, Galloway, and Angus cows; four 5-year-old and four 3-year-old Charolais × Angus crossbreds; five Angus × Galloway crossbred 2-year-olds; and five 2-year-old Herefords.

[1]Present address: Alberta Department of Agriculture, Edmonton, Alberta.

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Table 1. Means and standard deviations by month of test and breed of cow for 24-hour milk yield, calf milk consumption in June, and calf average daily gain from birth to weaning

Breed of cow	No.	Milk yield					Calf consumption (kg)	Calf ADG (kg)
		June	July	August	October	Average		
Hereford (mature)	8	7.3±1.17	5.4±1.02	4.2±0.92	3.8±1.07	5.2±1.69	6.2±1.57	0.71±0.09
Galloway (mature)	8	9.8±0.98	8.6±1.12	7.2±0.78	5.6±0.99	7.8±1.86	6.4±1.56	0.87±0.09
Angus (mature)	8	9.9±1.22	8.9±1.24	7.6±0.47	7.1±0.54	8.4±1.43	7.8±2.32	0.94±0.06
Charolais × Angus (3- and 5-yr-old)	8	7.7±0.95	8.3±0.96	7.6±1.38	5.8±0.86	7.3±1.37	8.5±2.58	0.94±0.10
Angus × Galloway (2-yr-old)	5	5.0±1.33	5.1±0.98	4.3±1.17	3.5±1.01	4.5±1.23	4.4±0.52	0.67±0.09
Hereford (2-yr-old)	5	3.7±0.72	4.3±0.64	3.8±0.90	3.1±0.78	3.7±0.83	3.8±0.69	0.57±0.08
Total	42	7.7±2.39	7.0±2.07	6.0±1.90	5.0±1.66	6.4±2.00	6.5±2.36	0.80±0.16

Milk tests were made on four occasions, in June, July, August and October, which corresponded roughly to the first, second, third and fifth months of lactation. In the milking procedure the cow was restrained in a squeeze, milk letdown was induced by intrajugular injection of 20 IU of oxytocin, and milk was removed by machine. On the evening before the test day, all milk was removed from the udder and the calf was separated from the cow. After a 12-hour overnight period, one side of the udder was milked and the yield obtained was multiplied by 4 to estimate 24-hour yield. This procedure was the same as that of Anthony *et al.* (1), except that 20 IU of oxytocin were injected intrajugularly rather than 40 units (USP) intramuscularly, and only one side of the udder was milked for the test. Before-and-after-suckling weighings of calves, four times over 24 hours, were used to estimate calf milk consumption.

Chemical analyses of milk for butterfat (BF), protein, solids-not-fat (SNF), and total solids (TS) were done according to AOAC (2) methods. Statistical analyses involving analyses of variance, correlations, and regressions followed methods outlined by Steel and Torrie (21).

RESULTS

Milk Yield

The 24-hour milk yields by month of test and breed–age group of cow are presented in Table 1. The overall average 24-hour milk yield was 6.4 ± 2.00 kg. Breed–age group averages for four milkings ranged from 3.7 kg per 24 hours for Hereford 2-year-olds to 8.4 kg for mature Angus cows.

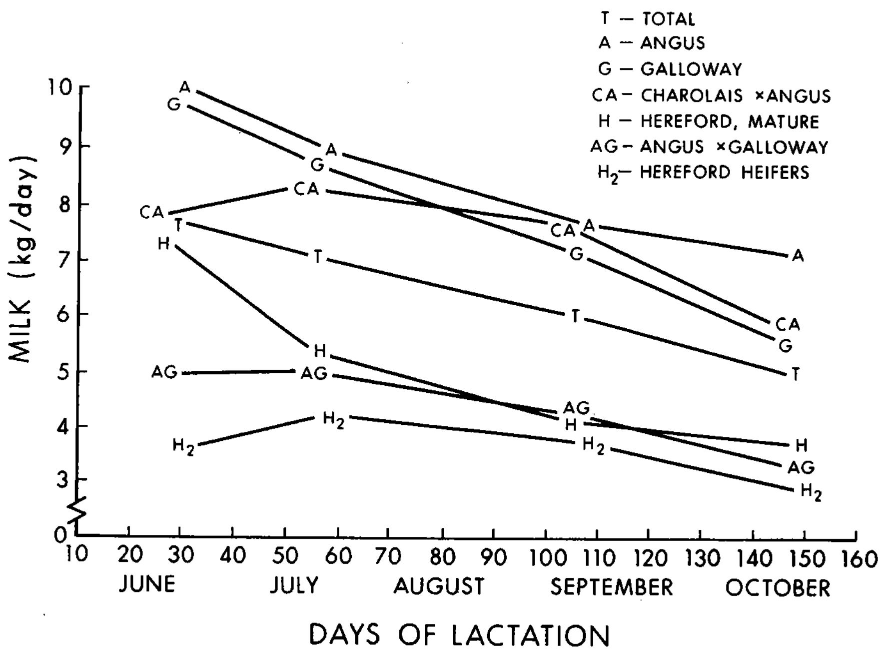

FIG. 1. Average 24-hour milk yield by breed–age group plotted against average day of lactation for four test milkings.

Milk yield declined over the lactation period (Fig. 1). The decline in milk yield for the total group was quite linear, the regression of milk yield on day of lactation being 0.02 kg with a correlation of −0.46 (significant at $P < 0.01$). Deviation from linearity was not significant, accounting for only 3% of the variance in milk yield.

Estimated calf consumption in June averaged 6.5 kg per 24 hours (ranging from 2.7 to 13.2 kg), which was 1.2 kg less than the average estimated yield for the same month. The correlation coefficient between the two variables was 0.58. Two groups showed an increase in milk yield from June to July (Charolais × Angus and Hereford 2-year-olds) and these had calf consumption estimates in June which exceeded the milk yield as measured manually.

Milk Composition

Breed–age group milk composition percentages are given in Table 2, as are average composition figures for each month of test. No significant differences among groups or month of test were found for any of the composition values. The BF percentage showed some variation between breed groups but the standard deviation within groups was relatively large. Means for percent protein among breed–age groups were quite uniform except from Hereford heifers, whose estimate had a large standard deviation. Percent SNF showed little variation among breed–age groups and percent TS followed the pattern for percent BF.

Table 2. Milk solids percentages, means and standard deviations by breed group and month of lactation

Factor	No.	BF %	Protein %	SNF %	TS %
Breed					
Hereford (mature)	8	3.9±0.39	3.4±0.10	9.0±0.17	13.0±0.31
Galloway	8	4.0±0.28	3.4±0.17	9.1±0.21	13.0±0.34
Angus	8	4.0±0.38	3.4±0.15	9.1±0.12	13.1±0.32
Charolais × Angus	8	3.7±0.37	3.5±0.15	9.2±0.19	12.9±0.34
Angus × Galloway	5	3.8±0.11	3.4±0.10	9.0±0.13	12.8±0.19
Hereford (2-yr-old)	5	3.6±0.46	3.8±0.60	9.1±0.25	12.7±0.58
Total	42	3.9±0.36	3.5±0.25	9.1±0.18	13.0±0.36
Month of lactation					
First		3.6±0.66	3.4±0.27	9.2±0.29	12.8±0.66
Second		3.8±0.58	3.4±0.20	9.0±0.39	12.8±0.50
Third		3.9±0.43	3.5±0.23	9.1±0.31	12.9±0.56
Fifth		4.4±0.64	3.4±0.23	9.2±0.31	13.6±0.75

Lactation trends are shown in the averages for each test month. Percent BF rose continuously through the testing period and this pattern was paralleled by percent TS, but these trends were not statistically significant. Protein and SNF percentage averages remained fairly constant over the test period.

Factors Related to Milk Yield and Composition

Average milk yield data from the three mature breed–age groups were analyzed to appraise the effect of breed of cow, and sex and birth weight of calf, on milk yield and composition. Analysis of variance (Table 3) indicated an important effect of breed of dam accounting for 82.5% of the variance in average milk yield in these data. Sex of calf had no measurable influence on milk production of the dam. Within the mature cow groups, calf birth weight was not significantly correlated with milk yield of dam.

Table 3. Mean squares and components of variance of milk yield by breed of dam and sex of calf for mature cow breed groups

Source	Degrees of freedom	Mean squares	Estimated component of variance	Component of variance (%)
Breed of cow	2	1785.10**	215.84	82.5
Sex of calf	1	7.82	−4.21	−1.6
Breed × sex	2	58.39	2.85	1.1
Error	18	47.00	47.00	18.0

**Significant at $P < 0.01$.

There was no detectable effect of breed of dam, sex of calf or birth weight of calf on any of the percentages of milk solids.

Relationships Among Milk Yield and Milk Constituents

Intercorrelations among milk yield for the four test months, average milk yield, and average milk composition percentages are given in Table 4. Intercorrelations among milk yield measured for the four test months were quite high ($r = 0.75$ to 0.91). Individual-month yield measurements were very highly correlated to the average yield ($r = 0.91$ to 0.96).

Correlations of yield with percent BF were low and positive but nonsignificant; with percent protein, were negative and approaching statistical significance at $P < 0.05$; with percent SNF, very near zero; and with percent TS, very low and nonsignificant.

Intercorrelations among individual milk composition estimates for the four test months, and the average of the four, are given in Table 5. Correlations among test months for various composition estimates were generally low and variable. Each test-month composition estimate showed reasonable and similar correlations ($r = 0.50$ or higher) with the average of the four tests for each milk component, with the exception of percent protein where three of the four correlations were below 0.50.

Relationship of Milk Yield and Composition to Calf Average Daily Gain

Individual milk yield estimates were correlated with the average daily gain (ADG) of calves in the preceding test period. The correlation coefficients were $r = 0.62$ for June milk yield and calf ADG from birth to June; $r = 0.75$ for July milk yield and calf ADG from June to July; $r = 0.56$ for August milk yield and calf ADG from July to August; and $r = 0.51$ for October milk yield and calf ADG from August to October.

Milk yield as measured in four test months was highly correlated with calf ADG from birth to weaning ($r = 0.73$ to 0.83) (Table 4). The average of four milk yield estimates had a similar correlation with calf ADG ($r = 0.84$). Milk composition percentages were essentially uncorrelated with calf ADG in these data (Table 4).

Table 4. Intercorrelations of milk yield, milk solids, and calf average daily gain to weaning ($N = 42$)

	1	2	3 Milk yield	4	5	6	7	8	9	10
	June	July	August	October	Av. yield	BF %	Protein %	SNF %	TS %	Calf ADG
1. June		.83	.75	.79	.91	.28	−.34	−.07	.23	.73
2. July			.90	.87	.96	.14	−.29	.07	.09	.83
3. August				.87	.93	.15	−.22	.04	.09	.81
4. October					.93	.12	−.23	.06	.09	.82
5. Average yield						.19	−.30	.02	.14	.84
6. BF %							−.11	−.30	.90	.02
7. Protein %								.43	.09	−.30
8. SNF %									.09	.03
9. TS %										−.04

$r = 0.30$ significant at $P < 0.05$
$r = 0.39$ significant at $P < 0.01$

Table 5. Intercorrelations of milk solids percentages for individual and total periods of lactation (N = 42)

Milk solid constituent	Month	June	July	August	October
Butterfat %	July	0.24			
	August	0.11	0.34		
	October	0.08	0.42	0.28	
	Average	0.65	0.78	0.54	0.61
Protein %	July	0.27			
	August	0.06	0.52		
	October	0.28	0.36	0.33	
	Average	0.32	0.39	0.45	0.66
Solids-not-fat %	July	0.09			
	August	0.16	−0.26		
	October	0.14	−0.19	0.57	
	Average	0.61	0.52	0.50	0.50
Total solids %	July	0.27			
	August	0.09	0.07		
	October	0.03	0.26	0.39	
	Average	0.65	0.69	0.53	0.61

r = 0.30 significant at $P < 0.05$
r = 0.39 significant at $P < 0.01$

The combined influence of milk yield and milk composition on calf ADG from birth to weaning was estimated by the use of ordered multiple regressions. Average milk yield accounted for 71.3% of the variance in calf ADG (regression coefficient of 71 ± 7 g per day, per kg milk per day). Percent TS accounted for an additional 2.7% and the inclusion of percentages of protein, SNF and BF accounted for only an additional 0.5%. Adding individual monthly recordings to the regression equation of average milk yield on calf ADG accounted for only 1.6% additional variance in calf ADG. July milk yield alone accounted for 68.2% of the variance in calf ADG, and the addition of October milk yield as a predictor accounted for an additional 3.7% of the variance. Including August and June milk yields accounted for only an additional 0.8% and 0.1% of the variance in calf ADG, respectively.

DISCUSSION

The average breed–age group milk yields of 3.7 to 8.4 kg per 24 hours recorded in this experiment are in the range of reported yields for beef cattle and some dairy × beef crossbreds (5, 6, 8, 11, 12, 16, 22).

Estimated milk yield declined on average from the first through the fourth test milking. Some beef and dairy–beef crossbred cows have been reported to show a peak in milk yield when testing was by weighings before and after suckling (22), and by milking under a dairy system (6). The nature of the difference in milk trends between dairy cows and range beef cows nursing calves as found by Gifford (12) were attributed to the effect of nursing. The milk yield of a range cow during the early stage of lactation, if in excess of calf capacity, would decline to the level of the calf's appetite. In the study reported here, there were indications that such was the case. Taking manual and calf-suckling techniques in early lactation as measures of milk yield and milk consumption, respectively, it was evident that on average there was more milk available to the calf than was being consumed. However, in the two breed–age groups where milk yield rose from the first to the second test, estimated calf consumption records were higher than records obtained by milking. This is in contrast to the other breed–age groups, where estimated consumption was below estimated production and milk yield subsequently dropped. Experiments with sheep, in which milk production of ewes with twins was compared with that of ewes with singles (7), demonstrated an effect of milk consumption on milk yield, as has work with pigs (9, 10).

The only milk composition records reported for beef cattle were for BF percentage. Dawson *et al.* (8) cited various studies which reported results near the 3.9% of the present experiment, with ranges of 3.1 to 4.4% for group averages. Individual variation was too great to detect differences, if any existed, between breed–age groups or month of test for any of the milk composition estimates. Protein averaged 3.5% and SNF 9.1%, with little variation among breed–age groups and considerable individual variation. Total solids averaged 13.0% and varied with percent BF.

Butterfat percentage increased throughout the lactation period, though this trend was not statistically significant. Reported BF percentages for dairy cattle normally show an initial decline, which was not detected in these tests. No lactation trends were detected for percent protein or SNF, while percent TS followed the trend for percent BF.

Among the mature breed–age groups, breed of cow was the most noticeable factor influencing average milk yield, accounting for 82.5% of the variance. Sex of calf had no measurable influence on milk yield of the dam in the present experiment, although milk consumption differences between sexes have been previously reported by Knapp and Black (14). Birth weight of calf also had no measurable relationship to milk yield of dam among the mature cows in this experiment.

There was no detectable difference in milk solids components among the breeds tested, but this does not rule out the importance of genetic effects in these traits. There was also no detectable effect of sex of calf or birth weight of calf on milk solids percentages of the dam, and there were perhaps no reasons to expect any unless they were mediated through an influence on milk yield.

High intercorrelations among individual milk yield estimates for the four test periods, and very high correlations of each test period estimated with the average of the four tests, indicate that the testing method was quite repeatable and probably reliable for appraising differences in milk yield among individuals and groups.

Intercorrelations of milk yield and milk component percentages are compared in Table 6 with those reported for dairy cattle by Robertson *et al.* (18) and Longley and Rennie (15). There is reasonable agreement between the correlations estimated in the present report and those of Robertson *et al.* for milk yield with milk component percentages. Intercorrelations among milk component percentages, however, agree with the published reports only in that percent BF was found to be highly correlated to percent TS, and protein and SNF percentages were found to be correlated. Other correlations as estimated

Table 6. Comparison of intercorrelations of milk yield and milk solids percentages from three sources

	BF %	Protein %	SNF %	TS %
Milk yield				
(*a*)*	−0.03 and −0.14	−0.03 and −0.26	−0.10 and −0.18	—
(*b*)	—	—	—	—
(*c*)	0.19	−0.30	0.02	0.14
BF %				
(*a*)		0.37 and 0.42	0.33 and 0.40	—
(*b*)		0.44 – 0.65	0.37 – 0.59	0.81 – 0.95
(*c*)		−0.11	−0.30	0.90
Protein %				
(*a*)			0.77 and 0.81	—
(*b*)			0.74 – 0.80	0.73 – 0.78
(*c*)			0.43	0.09
SNF %				
(*a*)				—
(*b*)				0.81 – 0.84
(*c*)				0.09

*(*a*)From Robertson *et al.* (18) (separate estimates among dams and daughters).
(*b*)From Longley and Rennie (15).
(*c*)Present report.

are quite discrepant, which may be a reflection of insufficient numbers, inadequate sampling, or confounding of breed or other effects. Estimates of milk component percentages were generally poorly correlated among test periods but reasonably correlated to the average of the four tests.

Gifford (12) reported an increased correlation between milk yield of dam and calf gains from the first to the second month, followed by a drop in relationship to the third and fourth months (r = 0.61, 0.71, 0.52 and 0.35, respectively). A more pronounced drop in correlation (r = 0.87 to 0.21) for the first to the fifth two-week period for lambs was reported by Owen (17). Salmon-Legagneur and Aumaitre (19) reported a drop in correlation from r = 0.64 to r = 0.09 from the second to the seventh week for piglets. The change in correlation between milk yield and calf gain in the preceding period, from the first to the fourth period in the present experiment, was not as marked as reported by Gifford but followed the same trend (r = 0.62, 0.75, 0.56 and 0.51, respectively). Consumption by calves of less than their dam's potential milk yield in the first month would result in a decreased milk yield, subsequently. This could lead to a lower correlation between milk yield and calf gain in the first month. By the second month the calf would still be heavily dependent on milk as the nutrient source, and the yield of the cow would presumably have become equated to some extent with the appetite of the calf. This would result in a higher correlation between milk yield and calf ADG. Subsequently, as calves began to eat more grass and milk was not the only nutrient source, the correlation of milk yield and calf gain would drop. Creep feeding and delayed weaning would also probably reduce the correlation, as suggested by Dawson *et al.* (8) and supported by Neville (16). The high overall relationship between calf growth and milk yield of dam in the present study may reflect dependency of the calf on the milk of its dam, because of no supplementary grain feeding and relatively young age (approximately 6 months) at the completion of the test.

Milk yield estimated in any month was highly predictive of calf ADG from birth to weaning. July milk yield had the highest correlation with calf ADG. A small improvement in predictability was obtained by using milk yield estimates for two months, but additional records did not improve the relationship. Average milk yield accounted for 71.3% of the variance in calf ADG. Only slight improvement in the prediction of calf gains was obtained by including the percentage of any milk solids component in a multiple regression equation. Low and nonsignificant correlations of milk component percentages and calf growth were also reported by Klett *et al.* (13). The low relationships of milk solids percentages to calf gains may be due to inadequacies in the method of establishing milk solids levels for any particular cow, or to a low variation in milk solids percentages between tested cows over the lactation.

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