EFFECTS OF MILK INTAKE ON FORAGE INTAKE AND PERFORMANCE OF SUCKLING RANGE CALVES[1]

R. P. Ansotegui[2], K. M. Havstad[3], J. D. Wallace[4] and D. M. Hallford[4]

Montana State University, Bozeman 59717 and New Mexico State University, Las Cruces 88003

ABSTRACT

A study to examine the relationships between milk intake, forage intake, and performance of Hereford-Angus suckling range calves was conducted during July, August, and September of 1984 and 1985. Twenty calves were used each year. The study was conducted at the Red Bluff Research Ranch located 56 km west of Bozeman, Montana. Average daily gain, milk intake (MI), forage digestibility, and fecal output (FO) were measured at 28-d intervals, beginning when the average calf age was 66 ± 4 d. Milk intake was estimated using weigh-suckle-weigh techniques. Total fecal collections were used to measure FO. Forage digestibility and rates of passage were determined using nylon bag in situ techniques and external markers in ruminally cannulated calves of the same age. Fecal output by calves increased as body weight and age increased. Milk intake was higher ($P < .05$) in 1985 than in 1984, but FO was higher ($P < .01$) in 1984 than in 1985. Fecal output by calves was negatively correlated to MI in July ($r = -.62$; $P < .05$) and August ($r = -.56$; $P < .05$). No significant correlations were detected between MI and ADG ($P > .10$). Forage intake estimates were derived from FO, rate of passage, and in situ digestibility values. During July, calves consumed .3 kg more forage for each kilogram of reduction in fluid MI ($P < .05$). In both August and September, calves consumed .6 kg more forage for each kilogram of reduction in fluid MI ($P < .10$). Calves maintained similar digestible energy (DE) intake both years, although the source of DE varied.
Key Words: Suckling, Calves, Milk, Forage, Intake

J. Anim. Sci. 1991. 69:899–904

Introduction

Net income from cow-calf operations is influenced most by calf weaning weight and percentage of calf crop weaned (Lindholn and Stonaker, 1957; Wiltbank, 1970). Gregory et al. (1950) and Drewery et al. (1959) stated that milk production of the dam exerts a major influence on weaning weight (WW) of the calf. Estimated correlations of milk intake (MI) to WW range from .12 to .88 (Neville, 1962; Furr and Nelson, 1964; Totusek et al., 1973; Kress and Anderson, 1974; Lusby et al., 1976). This relationship suggests that calf WW can be elevated by increasing MI. However, the assumption that the correlation between WW and MI is solely nutritional may be erroneous (Langlands, 1973; Morris and Wilton, 1976). Research has indicated that calves receiving less milk increase their forage intake (Baker et al., 1976; Le Du et al., 1976; Le Du and Baker, 1979; Boggs et al., 1980).

Other research indicates that high milk production may be detrimental to subsequent reproductive performance (Oxenreider, 1968; Short et al., 1972; Troxel et al., 1980; Acosta et al., 1983). Costs of increased milk production have not been completely investigated, and the relative importance of forage in the diet of suckling calves is unclear. Objectives of this study were to examine relationships

---

[1]Contribution No. J.2257 from Montana Agric. Exp. Sta.

[2]Dept. of Anim. and Range Sci., Montana State Univ.
[3]Jornada Exp. Range, USDA, ARS Las Cruces, NM.
[4]Dept. of Anim. and Range Sci., New Mexico State Univ.

Received September 26, 1988.
Accepted September 17, 1990.

TABLE 1. CHEMICAL COMPOSITION OF CALF DIETS BY SAMPLING PERIOD[a]

Constituent, %	July	August	September
CP[b]			
1984	12.6	9.7	10.6
1985	13.0	10.7	14.1
ADF[b]			
1984	42.5	42.3	39.6
1985	45.5	39.2	36.6
NDF[b]			
1984	64.8	65.7	62.3
1985	64.8	63.2	56.2
EE[b]			
1984	3.9	4.5	4.2
1985	2.5	4.8	5.7

[a]Least squares means, organic matter basis, July calf age = 66 to 94 d, August calf age = 95 to 123 d, and September calf age = 124 to 152 d.

[b]CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; and EE = ether extract.

between milk intake, forage intake, and performance of suckling range calves.

Materials and Methods

The study was conducted over a 2-yr period (1984 and 1985) in a 319-ha pasture at the Red Bluff Research Ranch, situated 56 km west of Bozeman, Montana on the northwest slope of the Madison Range. Elevation within the pasture ranges from 1,400 to 1,900 m. Annual precipitation averages from 350 to 406 mm (USDA-SCS, 1976). Rainfall between June 15 and September 30 was 129 mm for both years of the study. In 1980, the Soil Conservation Service classified the pasture as a silty range site in good condition; grasses composed 65% of the vegetation, and forbs and shrubs contributed the remaining 35%. Payne (1973) reviewed major range sites of Montana and categorized this pasture as foothill grassland with bluebunch wheatgrass as the principal forage species. Carrying capacity was estimated at 1.21 ha/animal unit month (AUM; Payne, 1973). For both years of the study, the stocking rate was 3.98 ha/AUM. Therefore, available forage was never a limiting factor and the quality of grazed forage remained adequate throughout the study (Table 1). Major grass species (Turner, 1985) included bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), prairie junegrass (*Koeleria pyramidata*), and needle and thread (*Stipa comata*). Twenty cow-calf pairs from the Montana State Prison Ranch were used each of the 2 yr. All cows were 1/4 Red Angus × 3/4 Hereford from a single Hereford sire, and all calves were steers from a single Red Angus sire. Cows and calves were placed in the pasture in June of each year when calf age was 45 ± 4 d, and data collection began when the calf age was 66 ± 4 d.

Milk intake of calves was estimated using 6-h weigh-suckle-weigh techniques. Upon arrival at the corrals, cows were separated from calves for 1 h. Calves were allowed to suckle after the 1-h separation to ensure that all cows were suckled at the same time. Cows then were separated from calves for 6 h, after which calves were weighed, allowed to suckle, and reweighed. Six-hour milk production was multiplied by 4 to estimate 24 h MI. All cow-calf pairs were used to estimate MI. Weigh groups were restricted to no more than seven cow-calf pairs each to more accurately observe potential weight loss associated with calf fecal and urine loss between weighings. Milk intake was estimated four times at 28-d intervals beginning when mean calf age was 66 d and terminating when mean calf age was 152 d. The same seven calves were fitted with total fecal collection bags three times/yr at 28-d intervals. Total fecal collection was conducted for 96 h following a 24-h bag adaptation period. Fecal bags were changed at 12-h intervals. Individual fecal collections were weighed and a representative sample from each calf was frozen for subsequent laboratory analyses. The eight 12-h fecal samples from each calf were analyzed individually for ADF and NDF (Goering and Van Soest, 1970) and DM and ash (AOAC, 1980). The eight individual 12-h weights were totaled within calf and divided by 4 to determine daily fecal output (FO).

Four contemporary ruminally cannulated calves from a companion study were used each year to collect extrusa samples to determine the chemical composition of grazed forage (Table 1). The same ruminally cannulated calves also were used to determine rumen kinetics using external markers and nylon bag techniques.

Undigested forage NDF and fecal NDF in conjunction with rate of passage were used to estimate forage intake. Neutral detergent fiber was selected over OM because NDF is less likely to be affected by endogenous OM and undigested milk constituents.

TABLE 2. DAILY FLUID MILK INTAKE OF CALVES BY SAMPLING PERIOD AND YEAR[a]

Year	Period			Total milk intake (84 d)
	July	August	September	
1984	7.9 ± 1.2[b]	5.2 ± .9[b]	6.0 ± 1.2[b]	534.8 ± 77.7[b]
1985	9.9 ± .6[bc]	9.7 ± 1.0[c]	9.6 ± 1.1[c]	817.6 ± 42.1[c]

[a]Least squares means ± SE, kilograms (n = 7). July calf age = 66 to 94 d, August calf age = 95 to 123 d, and September calf age = 124 to 152 d.

[b,c]Period means in a row with different superscripts differ ($P < .05$) and means in a column with different superscripts differ ($P < .05$).

Digestible organic matter (DOM) for each period was determined in a companion study using the nylon bag techniques of Uden and Van Soest (1984). Rate of OM disappearance was estimated by procedures described by Mertens and Loften (1980). Digestible energy of grazed forage was estimated by the following two equations: 3.6 × DOM = Mcal ME/kg forage (Van Es, 1978) and ME/.82 = DE (NRC, 1984). Thirty-six-hour in situ OM disappearance values were used to estimate DOM; particulate turnover estimates (Grovum and Williams, 1973) using sodium dichromate-mordanted fiber (Uden et al., 1980) were 30.5, 32.7, and 36.7 h in July, August, and September 1985, respectively. A DE value of .71 Mcal DE/kg was used for fluid milk (NRC, 1971). Calf age was the same and mean BW also was not different ($P > .10$) between years (1984, 114.5 kg; 1985, 110.4 kg).

Correlation analyses used the Pearson product-moment correlation option (SAS, 1984). Regression was used to determine slope of MI and FO (SAS, 1984). Analysis of variance for ADG, FO, and MI was conducted using a model that included effects for year, sampling period, and period × year. Effects in the model were tested with animal (year × period) as the error term (SAS, 1984).

Results and Discussion

Milk intake in 1984 was not different ($P > .10$) between July (7.9 ± 1.2 kg/d), August (5.2 ± .9 kg/d), and September (6.0 ± 1.2 kg/d), although MI tended to decline from July to August and then to increase in September. The increase in MI from August to September possibly was a response to August rains and increased forage quality (Table 2). Milk intake in 1985 remained constant at approximately 9.7 kg/d throughout the three collection periods. Milk intake was higher ($P < .05$) in August (9.7 ± 1.0 kg/d) and September (9.6 ± 1.1 kg/d) 1985 than in August (5.2 ± .9 kg/d) and September (6.0 ± 1.2 kg/d) 1984. Total MI (84 d) also was higher ($P < .05$) in 1985 (817.6 ± 42.1 kg) than in 1984 (534.8 ± 77.7 kg; Table 2). Daily FO by calves increased with calf age (Table 3), but no relationships were detected between ADG and FO during any period ($P > .10$). Fecal output was higher ($P < .01$) during all collection periods in 1984 than in 1985 (Table 3). When data from both years were combined, FO by calves was negatively correlated with MI in July ($r = -.62$; $P < .05$) and August ($r = -.56$; $P < .05$). No significant correlations ($P > .10$) were observed between MI and ADG within period; however, total 84-d MI was related to total 84-d gain in 1984 ($r = .76$, $P < .05$) but not in 1985 or in the combined analyses (Table 4). This finding is in agreement with Melton et al. (1967). These researchers measured MI at approximately 30-d intervals and found MI and ADG to be correlated only in the first period when mean calf age was 64 d.

Average daily gain within period tended to be higher ($P > .10$) in 1984 than in 1985 (Table 5). In both years, lowest ADG was observed in July; ADG in August and Septem-

TABLE 3. DAILY FECAL DRY MATTER OUTPUT (KILOGRAMS) OF CALVES BY SAMPLING PERIOD AND YEAR[a]

Year	Period		
	July	August	September
1984	.49 ± .04[b]	1.04 ± .06[b]	1.28 ± .07[b]
1985	.24 ± .04[c]	.47 ± .06[c]	.72 ± .07[c]

[a]Least squares means ± SE; July calf age = 66 to 94 d, August calf age = 95 to 123 d, and September calf age = 124 to 152 d.

[b,c]Means in a column with different superscripts differ ($P < .01$).

TABLE 4. CORRELATIONS BETWEEN MILK INTAKE AND AVERAGE DAILY GAIN BY SAMPLING PERIOD WITHIN YEAR AND ACROSS YEARS[a]

Period	r	P-value[b]
1984		
July	−.12	.70
August	.23	.60
September	.60	.15
84-d total	.76	.04
1985		
July	−.02	.90
August	−.08	.80
September	.45	.30
84-d total	.18	.70
1984 & 1985		
July	−.15	.50
August	−.15	.60
September	.21	.40
84-d total	.17	.55

[a]Milk intake, kg/d; ADG, kilogram; July calf age = 66 to 94 d, August calf age = 95 to 123 d, and September calf age = 124 to 152 d.

[b]Probability r = 0.

ber were nearly the same within year (Table 5).

To estimate the amount of forage consumed by calves as milk production lessened, a simple ratio of milk and forage consumption was calculated within month across year. During July, regression analysis revealed that 12.7 kg of consumed milk was associated with 1 kg of FO ($P < .05$). Likewise, the digestibility estimate of forage being consumed by calves during this time period was 75%, indicating that 1 kg of FO was associated with 4 kg of forage intake. Therefore, a ratio of 3.2:1 milk to forage during July was required to yield 1 kg of feces. Thus, calves ate .3 kg more forage for each kilogram of reduction in fluid MI. In both August and September, regression analysis revealed that 5.2 kg of consumed milk was associated with 1 kg of FO ($P < .10$), and the digestibility estimate was 67%. Thus, the ratio of milk and forage required to yield 1 kg of feces was 1.7:1, implying that the calves ate .6 kg more forage for each kilogram of reduction in fluid MI. The twofold increase in forage intake from July to August may be a function of calf age and rumen development.

This finding is supported by the study of Wyatt et al. (1977) in which estimates of milk and forage intake were compared among calves reared as singles or as simulated twins. Simulated twins were produced by forced adoption of a second newborn calf to cows at the time of birth of their natural calf. Calves nursing as singles consumed 6.6 kg of milk daily, compared with the calculated amounts of 5.6 kg for the natural twin and 3.6 kg for the adopted twin. Estimated relative forage consumption averaged over two periods expressed as a percentage of body weight was 2.3, 3.3, and 3.9% for singles and natural and adopted twins, respectively.

Broesder et al. (1989) demonstrated that a reduction in MI had a linear effect on forage intake; however, total OMI did not differ and neither NDF nor DM digestibility was affected by milk reduction.

Earlier studies also indicated that suckling calves increase their forage intake to compen-

TABLE 5. DIGESTIBLE ENERGY INTAKE OF CALVES AND DIGESTIBLE ENERGY INTAKE PER KILOGRAM OF GAIN[a]

Period	Mcal DE intake from forage	Mcal DE intake from milk	Total Mcal DE intake/d	ADG, kg	Mcal DE intake/kg gain
July					
1984	4.2	5.6	9.8	.83	11.8
1985	2.2	7.0	9.2	.78	11.8
August					
1984	9.0	3.7	12.7	.92	13.8
1985	4.2	6.9	11.1	.84	13.2
September					
1984	7.4	4.3	11.7	.91	12.9
1985	4.5	6.8	11.3	.83	13.6

[a]July calf age = 66 to 94 d, August calf age = 95 to 123 d, and September calf age = 124 to 152 d.

sate for reduced MI (Baker et al., 1976; Le Du et al., 1976; Boggs et al., 1980). Similar results have been shown with suckling lambs (Langlands, 1972, 1973).

Digestible energy intake estimates, and estimates of Mcal DE required per kilogram of calf gain are presented in Table 5. In 1984, calves consumed more of their total DE intake from grazed forage than from milk, but in 1985 calves received more of their DE intake from milk than from forage. Although the primary source of DE was reversed between years, total DE intake by calves within each period was similar. Baker et al. (1976) also noted milk and herbage intakes of calves to be related inversely when calves consumed similar amounts of ME/unit of live weight. Estimates of Mcal DE required per kilogram of gain from this study were similar between year within period and agree with the requirement of 13.4 Mcal DE/kg gain reported by Bailey and Lawson (1981) for suckling range calves of ages similar to the ages of those used in the present study.

With higher ($P < .01$) forage intake in 1984, one would expect a higher requirement for gain because of higher energy costs for grazing. The lack of difference may be attributed partly to year differences in water sources. Because of reduced snow-pack in the winter of 1984–1985, only one water source (located at the south end of the pasture) was available in August and September 1985, whereas four water sources distributed throughout the pasture were available during all periods in 1984. Similarities observed between ADG each year and total DE intake within period each year, even though source of DE intake was variable, suggest that forage intake by suckling calves may be under metabolic control rather than being limited solely by rumen fill. Ørskov et al. (1973) and Le Du and Baker (1979) hypothesized that lactose may control intake in young ruminants. Previous calf studies (Roy, 1958; Marshall, 1975; Baker et al., 1976; Le Du et al., 1976; Boggs et al., 1980) also indicate that when adequate forage is available calves compensate for reduced MI by increasing forage consumption, thereby maintaining similar weight gains.

Implications

Results from this study indicate that calves nursing low-milk-producing cows consume more forage than those calves nursing high-producing cows. The increased forage consumption by the calf does not imply that more forage is necessary for the low-producing cow and her calf. Future research should evaluate total forage consumed by the cow-calf pair. Additionally, research with suckling calves and variable milk intake should include rebreeding performance of the cows and performance of subsequent calves.

Literature Cited

Acosta, B., G. K. Tarnavsky, T. E. Platt, D. L. Hamernik, J. L. Brown, H. M. Schoenemann and J. J. Reeves. 1983. Nursing enhances the negative effect of estrogen of LH release in the cow. Proc. West. Sect. Am. Soc. Anim. Sci. 34:203.

AOAC. 1980. Official Methods of Analysis (13th Ed.). Association of Official Analytical Chemists, Washington, DC.

Bailey, C. B. and J. E. Lawson. 1981. Estimated water and forage intakes in nursing range calves. Can. J. Anim. Sci. 61:415.

Baker, R. D., Y.L.P. Le Du and J. M. Barket. 1976. Milk-fed calves. 1. The effect of milk intake upon the herbage intake and performance of grazing calves. J. Agric. Sci. (Camb.). 87:187.

Boggs, D. L., E. F. Smith, R. R. Schalles, B. E. Brent, L. R. Corah and R. J. Pruitt. 1980. Effects of milk and forage intake on calf performance. J. Anim. Sci. 51:550.

Broesder, J. T., M. B. Judkins, L. J. Krysl, S. A. Gunter and R. K. Barton. 1989. Forage intake, digestibility and digesta kinetics in calves receiving 30 or 60% milk reduction and ad libitum hay. J. Anim. Sci. 67(Suppl. 2):208 (Abstr.)

Drewery, K. J., C. J. Brown and R. S. Honea. 1959. Relationships among factors associated with mothering ability in beef cattle. J. Anim. Sci. 18:938.

Furr, R. D. and A. B. Nelson. 1964. Effect of level of supplemental winter feed on calf weight and milk production of fall calving range beef cows. J. Anim. Sci. 23:775.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis (apparatus; reagents, procedures, and some applications). Agric. Handbook 379. ARS, USDA, Washington, DC.

Gregory, K. E., C. T. Blum and M. L. Baker. 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. J. Anim. Sci. 9:338.

Grovum, W. L. and V. J. Williams. 1973. Rate of passage of digesta in sheep. 4. Passage of marker through the alimentary tract and the biological relevance of rate-constants derived from the changes in concentration of marker in the faeces. Br. J. Nutr. 30:313.

Kress, D. D. and D. C. Anderson. 1974. Milk production in Hereford cattle. Proc. West. Sect. Am. Soc. Anim. Sci. 25:37.

Langlands, J. P. 1972. The growth and herbage consumption of grazing Merino and Border Leicester lambs reared by their mothers or fostered by ewes of the other breed. Anim. Prod. 14:317.

Langlands, J. P. 1973. Milk and herbage intakes by grazing lambs born to Merino ewes and sired by Merino, Border Leicester, Corriedale, Dorset horn and Southdown rams. Anim. Prod. 16:285.

Le Du, Y.L.P. and R. D. Baker, 1979. Milk-fed calves. 5. The effect of a change in milk intake upon the herbage intake and performance of grazing calves. J. Agric. Sci. (Camb.) 92:443.

Le Du, Y.P.L., R. D. Baker, and J. M. Barker. 1976. Milk-fed calves. 2. The effect of length of milk feeding period and milk intake upon herbage intake and performance of grazing calves. J. Agric. Sci. (Camb.) 87:197.

Lindholn, H. B. and H. H. Stonaker. 1957. Economic importance of traits and selection indexes for beef cattle. J. Anim. Sci. 16:998.

Lusby, K. S., D. F. Stephens and R. Totusek. 1976. Effects of milk intake by nursing calves on forage intake on range and creep intake and digestibility in drylot. J. Anim. Sci. 43:1066.

Marshall, D. A. 1975. Factors affecting efficiency to weaning in Angus, Charolais and reciprocal cross cows. M. S. Thesis. South Dakota State Univ., Brookings.

Melton, A. A., J. K. Riggs, L. A. Nelson and T. C. Cartwright. 1967. Milk production, composition and calf gains of Angus, Charolais and Hereford cows. J. Anim. Sci. 26:804.

Mertens, D. R. and J. R. Lofton. 1980. The effect of starch on forage fiber digestion kinetics in vitro. J. Dairy Sci. 63: 1437.

Morris, C. A. and J. W. Wilton. 1976. Influence of body size on the biological efficiency of cows: A review. Can. J. Anim. Sci. 56:613.

Neville, W. E. 1962. Influence of dam's milk production and other factors on 120- and 240-day weight of Hereford calves. J. Anim. Sci. 21:315.

NRC. 1971. Atlas of Nutritional Data on United States and Canadian Feeds. National Academy Press, Washington, DC.

NRC. 1984. Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, DC.

Ørskov, E. R., C. Fraser and R. Pirie. 1973. The effect of bypassing the rumen with supplements of protein and energy on intake of concentrates by sheep. Br. J. Nutr. 30:361.

Oxenreider, S. L. 1968. Effects of suckling and ovarian function on postpartum reproductive activity in beef cows. Am. J. Vet. Res. 29:2099.

Payne, G. F. 1973. Vegetative rangeland types in Montana. Montana Agric. Exp. Sta. Bull. No. 671, Bozeman.

Roy, J.H.B. 1958. The nutrition of the early weaned dairy calf: A review. Dairy Sci. Abstr. 20:2.

SAS. 1984. SAS User's Guide: Statistics. SAS Inst., Inc., Cary, NC.

Short, R. E., R. A. Bellows, E. L. Moody and B. E. Howland. 1972. Effects of suckling and mastectomy on bovine postpartum reproduction. J. Anim. Sci. 34:70.

Totusek, R., D. W. Arnett, G. L. Holland and J. V. Whiteman. 1973. Relation of estimation method, sampling interval and milk consumption to milk yield of beef cows and calf gain. J. Anim. Sci. 37:153.

Troxel, T. R., D. J. Kesler, R. C. Noble and S. E. Carlin. 1980. Ovulation and reproductive hormones following steroid pretreatment, calf removal and GnRH in postpartum suckled beef cows. J. Anim. Sci. 51:652.

Turner, M. E. 1985. The forage intake of supplemented cows grazing winter foothill rangelands of Montana. M. S. Thesis. Montana State Univ., Bozeman.

Uden, P., P. E. Colucci and P. J. Van Soest. 1980. Investigation of chromium, cerium and cobalt as markers in digesta rate of passage studies. J. Sci. Food Agric. 31:625.

Uden, P. and P. J. Van Soest. 1984. Investigations of the in situ bag technique and a comparison of the fermentation in heifers, sheep, ponies and rabbits. J. Anim. Sci. 58:213.

USDA-SCS. 1976. Climax vegetation in Montana: based on soils and climate. USDA-SCS, Bozeman, MT.

Van Es, A.J.H. 1978. Feed evaluation for ruminants. 1. The systems in use from May 1977 onwards in the Netherlands. Livest. Prod. Sci. 5:331.

Wiltbank, J. N. 1970. Research needs in beef cattle production. J. Anim. Sci. 31:755. Wyatt, R. D., M. B. Gould and R. Totusek. 1977. Effects of single vs simulated twin rearing on cow and calf performance. J. Anim. Sci. 45:1409.