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Escape protein and weaning effects on calves grazing meadow regrowth

GREGORY P. LARDY, DON C. ADAMS, TERRY J. KLOPFENSTEIN, RICHARD T. CLARK, AND JUNE EMERSON

Lardy is assistant professor, Animal and Range Science Department, North Dakota State University, Fargo, N.D. 58105; Adams and Clark are professors, University Nebraska-Lincoln, West Central Research and Extension Center, 461 University Drive, North Platte, Nebr. 69101; Klopfenstein is professor, Dept. of Animal Science, University Nebraska-Lincoln, Lincoln, Nebr. 68583-0908; Emerson is research aid at the University Nebraska-Lincoln, Gudmundsen Sandhills Laboratory, Whitman, Nebr. 69366. At the time of this research, Lardy was research assistant, Dept. of Animal Science, University Nebraska-Lincoln, Nebr.

Abstract

Forty spring-born calves grazing subirrigated meadow regrowth after haying in July were assigned to 2 weaning and 2 supplementation treatments in fall of 1995 and 1996. Weaning treatments were weaning on 1 September or nursing during the duration of the trial. Supplementation treatments were no supplement or supplemental undegraded intake protein (UIP). An 80:20 (dry matter basis) blend of sulfite liquor treated soybean meal and feather meal was the source of undegraded intake protein (undegraded intake protein = 45% of supplement dry matter). Supplemented nursing calves received 0.50 kg of supplement daily whereas supplemented weaned calves received 0.91 kg of supplement daily. Weaned and nursing calves grazed subirrigated meadow regrowth throughout the trial. The trials were conducted from 17 October to 18 November 1995 and 5 September to 4 November 1996. Milk intake was measured by the weigh-suckle-weigh technique. Diet samples collected from ruminally cannulated calves after rumen evacuation averaged 12.5% crude protein and 54.8% in vitro organic matter digestibility. No supplementation x weaning management interactions were detected ($P > 0.18$). Nursing calves had greater weight gains (0.95 vs. 0.59 kg day^{-1}; $P = 0.001$) and lower forage intakes (2.36 vs. 2.96 kg day^{-1}; $P = 0.009$) than weaned calves. Supplementation with undegraded intake protein increased ($P = 0.03$) daily gains of calves compared to nonsupplemented calves 0.88 vs 0.66 kg day^{-1}, respectively. Forage intake as a percentage of body weight tended to be higher in non-supplemented calves ($P = 0.09$). However, total intake (forage plus supplement) as a percentage of body weight tended to be higher in supplemented calves ($P = 0.14$). Total intake (kg day^{-1}) was greater ($P = 0.01$) for calves supplemented with undegraded intake protein. Milk intake did not differ between supplemented and unsupplemented calves ($P > 0.52$). We concluded that subirrigated meadow regrowth forage was limiting in metabolizable protein and that milk represents an important source of metabolizable protein for grazing calves.

Key Words: undegraded intake protein, beef calves, forage intake, forage digestibility

Resumen

40 becerros nacidos en primavera, que apacentaban el rebrote de praderas subirrigadas después de segadas para heno en julio, se asignaron a 2 tratamientos de destete y 2 tratamientos de suplementación en otoño de 1995 y 1996. Los tratamientos de destete fueron: destetarlos el 1 de septiembre o amamantarlos durante la duración del experimento. Los tratamientos de suplementación fueron: no suplementación y suplementación de proteína no-degradada (PND). La fuente de proteína no-degradada fue una mezcla (80:20% en base seca) de pasta de soya tratada con licor de sulfito y harina de pluma (Proteína no-degradada = 45% de la materia seca suplementada). Los becerros amamantados suplementados recibieron 0.50 kg diarios de suplemento mientras que los becerros destetados suplementados recibieron 0.91 kg de suplemento al día. Durante el período de conducción del experimento los becerros destetados y los amamantados apacentaron el rebrote de las praderas subirrigadas. Los ensayos se condujeron del 17 de octubre al 18 de noviembre de 1995 y del 5 de septiembre al 4 de noviembre de 1996. El consumo de leche se midió mediante la técnica de peso-amamantamiento-peso. Las muestras de la dietas, colectadas de becerros con cánula ruminal y después de la evacuación del rumen, promediaron 12.5% de proteína cruda y 54.8% de digestibilidad in vitro de la materia orgánica. No se detectaron interacciones ($P > 0.18$) entre la suplementación y los sistemas de destete. Los becerros amamantados tuvieron mayores ganancias de peso (0.95 vs 0.59 kg día^{-1}; $P = 0.001$) y menores consumos de forraje que los becerros destetados (2.36 kg día^{-1} vs 2.96 kg día^{-1}; $P = 0.009$). La suplementación de proteína-no degradada aumentó las ganancias diarias de peso ($P = 0.03$) de los becerros suplementados en comparación con los no suplementados 0.88 vs 0.66 kg día-1 respectivamente. El consumo de forraje expresado como porcentaje del peso vivo tendió a ser mas alto en los becerros sin suplementar .($P = 0.09$). Sin embargo, el consumo total (forraje + suplemento) expresado como porcentaje de peso vivo tendió a ser mayor en los becerros suplementados ($P = 0.14$). El consumo total (kg día^{-1}) fue mayor ($P = 0.01$) en los becerros suplementados con proteína no-degradada. El consumo de leche no difirió entre becerros con y sin suplemento ($P > 0.52$). Concluimos que el rebrote de las praderas subirrigadas estuvo limitado en proteína metabolizable y que la leche representa una importante fuente de proteína metabolizable para los becerros en apacentamiento.

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Milk represents an important source of nutrients for the nursing calf (Blaxter and Wood 1952, Baker et al. 1976, Le Du et al. 1976, Wyatt et al. 1977, Sowell et al. 1996). As a result of the esophageal groove reflex, milk bypasses rumen fermentation and is digested and absorbed in the abomasum and small intestine (Ruckebusch 1988). The protein in milk represents an important contribution to the metabolizable protein supply of the nursing calf. The nursing calf has higher relative protein requirements than more mature animals, because greater amounts of protein are needed for lean growth, relative to fat accretion (NRC 1996).

When cattle graze growing or vegetative cool-season grasses, ruminal ammonia concentrations generally do not limit microbial growth and fermentation. However, because the protein in these grasses is readily degradable in the rumen (Lardy1997), large amounts of nitrogen can be absorbed as ammonia before reaching the duodenum (Beever and Siddons 1986). Therefore, metabolizable protein may be limiting in these forages despite their relatively high crude protein contents, especially when metabolizable protein requirements of the grazing ruminant are high (e.g., growth or lactation). Undegraded intake protein was limiting for nursing calves grazing native Sandhills range during summer (Hollingsworth-Jenkins 1994).

Numerous studies have evaluated the effects of early weaning on the performance of cows and calves, (Lusby et al. 1981, Harvey and Burns 1988, Grimes and Turner 1991a, 1991b). In these studies, early weaned calves were generally fed large amounts of grains, in a non-grazing setting. Lamb et al. (1997) reported that weaned calves gained 0.56 kg day^{-1} vs.1.09 kg day^{-1} for calves nursing cows grazing subirrigated meadow in September through October. Our objectives were to evaluate the effects of milk and supplemental undegraded intake protein on calf body weight gain, forage intake, and forage digestibility by weaned and nursing calves grazing subirrigated meadow regrowth in the Nebraska Sandhills.

Materials and Methods

The study was conducted at the University of Nebraska-Lincoln Gudmundsen Sandhills Laboratory (elevation 1,073 m, 42°05' N, 106° 26' W) near Whitman, Nebr. Forty March and April-born crossbred (1/4 Hereford, 1/4 Angus, 1/4 Simmental, and 1/4 Gelbvieh) steer and heifer calves were assigned in 1995 and 1996 to 2 weaning and 2 supplementation treatments as shown in Table 1. In 1995 the trial was initiated 5 September, but calves did not readily consume supplements until mid-October; therefore, the data are reported from 17 October to 18 November. In 1996, calves consumed supplements readily from the outset, and the trial lasted from 5 September to 4 November. Calves grazed subirrigated meadow regrowth after haying in July each year. Weaning treatments were: 1) weaning 1 September, or 2) nursing throughout the trial. Supplementation treatments were: 1) no supplementation, or 2) supplemental undegraded intake protein. Supplement composition is listed in Table 2 and it was formulated using a blend of sulfite-liquor-treated soybean meal (Cleale et al. 1987) and feather meal. Weaned calves that received supplement were individually fed 0.91 kg of supplement daily, whereas nursing calves received 0.50 kg of supplement daily (dry matter basis). Supplement amounts were based on the metabolizable protein requirement calculated as described by Wilkerson et al. (1993) and metabolizable protein supply calculated as described by Burroughs et al. (1974). Body weight was estimated to be 189.5 kg and average daily gain was estimated to be 1.1 kg day^{-1} (Lamb et al. 1997). Metabolizable protein requirement for maintenance was 3.8 g of metabolizable protein/kg of body weight $^{0.75}$(3.8 X 189.5$^{0.75}$) = 194 g; metabolizable protein requirement for gain was 305 g of metabolizable protein/kg gain (305 X 1.1) = 348 g, and total metabolizable protein requirement was 194 g + 348 g = 542 g day^{-1} (Wilkerson et al. 1993). Subirrigated meadow regrowth was estimated to be 12% crude protein, 1.1% undegraded intake protein, and 60% TDN (Lardy 1997). Forage intake by nursing calves was estimated to be 1.5% of body weight or 2.84 kg (Hollingsworth-Jenkins 1994). Net synthesis of bacterial crude protein was assumed to be 13% of the TDN intake (Burroughs et al. 1974). Consequently, bacteria would supply 142 g of metabolizable protein (2.84 kg of organic matter intake X 60% TDN X 13% efficiency X 80% digestibility X 80% true protein). Milk intake by nursing calves was estimated to be 8.2 kg day^{-1} (NRC 1996) which would supply 223 g metabolizable protein (8.2 kg X 3.4% CP X 80% digestibility). Forage was estimated to supply 25 g of metabolizable protein (2.84 kg X 1.1% undegraded intake protein X 80% digestibility). Hence, total metabolizable protein supply for the nursing calf would be 390 g, with a resulting calculated deficiency of 152 g of metabolizable protein (542 g requirement – 390 g supply). For weaned calves, forage intake was estimated at 2.5% of body weight (Le Du et al. 1976, Boggs et al. 1980). Resulting supply of metabolizable protein from bacteria was estimated to be 237 g. Forage supply of metabolizable protein was estimated to be 42 g, resulting in a metabolizable protein supply of 279 g (237 g + 42 g). For the weaned calf, the resulting deficiency would be 263 g (542 g requirement – 279 g supply). The sulfite liquor-treated soybean meal:feather meal supplement was estimated to be 52% crude protein and 70% of the crude protein was estimated to

Table 1. Number of steer and heifer calves assigned to weaning and supplement treatments in 1995 and 1996.

Item	Treatment: Nursing no supplement	Nursing with supplement	Weaned no supplement	Weaned with supplement
1995				
Steers	5	5	5	5
Heifers	6	4	5	5
1996				
Steers	7	7	5	5
Heifers	3	4	4	5

Table 2. Ingredients, crude protein (CP), undegraded intake protein (UIP) and invitro organic matter digestibility (IVOMD) of supplement fed to weaned and nursing calves (dry matter basis).

Item	%
Sulfite Liquor Treated Soybean Meal	80.0
Feather Meal	20.0
CP	57.3
IVOMD	79.5
UIP, % CP1	78.8

[1]Determined using ammonia release procedure (Britton et al. 1978).

be undegraded intake protein. Actual values for the trial are reported in Table 2. Hence, resulting feeding levels for weaned and nursing calves based on estimated deficiencies in metabolizable protein were 903 g and 522 g calf^{-1} day^{-1}, respectively. Calculations based on data from the trial resulted in a deficiency of 175 g and 285 g of metabolizable protein for nursing and weaned calves, respectively.

Cows and calves grazed a 33 ha pasture during the trial. Standing herbage was estimated to be 2,250 kg/ha (dry basis) at the beginning of the trial.

Calves were gathered daily at 0730 hours, sorted into individual pens (0.76 m X 2.54 m), and individually fed supplements. A small sample of supplement was collected weekly and composited for each year. In 1995, to prevent nursing by weaned calves, the subirrigated meadow pasture was split into 2 pastures. Nursing calves grazed on one side and weaned calves on the other. Each day following supplementation, nursing and weaned calves rotated pastures, so that over the course of the trial each group of calves grazed each side a similar number of days. In 1996, nursing and weaned calves were pastured together and observed several times in the a.m. daily for cross nursing. No nursing by weaned calves was observed.

The subirrigated meadow soils were classified as Gannet-Loup fine sandy loam (course-loamy mixed mesic Typic Haplaquoll). Dominant vegetation on the subirrigated meadow site was smooth bromegrass (*Bromus inermis* Leyss.), redtop (*Agrostis gigantea* Roth), timothy (Phleum pratense L.), slender wheatgrass [*Elymus trachycaulum* (Link) Gould ex Shinn.], quackgrass [*Elytrigia repens* (L.) Nevski.], Kentucky bluegrass (*Poa pratensis* L.), prairie cordgrass (*Spartina pectinata* Link), and several species of sedges (*Carex* spp.), and rushes (*Juncus* spp.). Less abundant grass species were big bluestem (*Andropogon gerardii* var. gerardii Vitman), indiangrass [*Sorghastrum nutans* (L.) Nash], and switchgrass (*Panicum virgatum* L.). Red clover (*Trifolium pratense* L.) was the most abundant forb.

Calves were weighed on 17 October and 18 November 1995 and 5 September and 4 November 1996. Milk intake by nursing calves was determined by weigh-suckle-weigh on 4 November 1995 and 19 October 1996. The day before the weigh-suckle-weigh procedure, calves were separated from cows at 1400 hours, allowed to nurse at 1800 hours, and separated overnight. At 0700 hours the next day calves were weighed, allowed to nurse, and weighed again. Twenty-four hour milk intakes were calculated by dividing overnight milk intake by 13 and multiplying by 24.

Fecal output by steer calves was determined 30 October through 3 November 1995 and October 14 through 18 1996. Each steer calf was dosed with an intraruminal continuous chromium (Cr) releasing device[1] 5 days before the 5-day fecal collection period. Fecal grab samples were obtained from each steer calf at approximately 0800 hours each day of the collection period. Six steers in 1995 (avg. body weight = 236 ± 17.5 kg) and 5 steers in 1996 (avg. body weight = 175 ± 19.3 kg) were used to perform total fecal collections. Steers used for total fecal collections had been weaned and received no supplement. Steers used for total collections were dosed with the same intraruminal continuous Cr releasing device as the steers on the trial and fitted with fecal collection bags for total fecal collection to obtain a correction factor for fecal output (Adams et al. 1991a, Hollingsworth et al. 1995). The correlation factor was 0.731 for 1995 and 0.897 for 1996. Feces collected in fecal collection bags was weighed, mixed, subsampled (300 to 500 g), and emptied. In 1995, bags were emptied daily at 0800. In 1996, fecal bags were emptied twice daily at 0800 and 1700 during the 5-day fecal collection period.

Forage diet samples were collected with 3 esophageally fistulated cows and 3 ruminally fistulated nursing calves. Calves were fistulated in late July before initiation of the trial. Cows had been fistulated 2 to 4 years previously as described by Adams et al. (1991b) with modifications for adult cattle. Surgical preparations and post-surgical procedures were reviewed and approved by the University of Nebraska Institutional Animal Care and Use Committee. Esophageal masticate samples were collected in screen-bottom bags and immediately frozen. Ruminal contents were evacuated, and the rumen was wiped with a damp sponge to remove digesta in order to prevent contamination of diet samples. Calves were allowed to graze for 45 to 60 minutes, and diet samples were collected via the ruminal cannula and immediately frozen.

All fecal and extrusa samples were stored frozen until chemical analyses were performed. Extrusa and fecal samples were freeze dried. Fecal and supplement samples were ground to pass a 1-mm screen in a Wiley Mill. Extrusa samples were ground to pass a 2-mm screen in a Wiley Mill for analysis of diet protein degradability. Extrusa samples were ground to pass a 1-mm screen in a Wiley Mill for analysis of dry matter, organic matter, crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), and in vitro organic matter digestibility (IVOMD). Dry matter, organic matter, and crude protein of extrusa and supplement were determined by standard methods (AOAC 1990). Extrusa NDF was determined according to Van Soest et al. (1991), and extrusa ADF by the method of Van Soest (1963). In vitro organic matter digestibility of extrusa and supplement samples was determined by the modified procedures of Tilley and Terry (1963) with the addition of 1 g of urea to the inoculum-buffer mixture (Weiss 1994). Fecal samples were analyzed for Cr concentration by atomic absorption spectrophotometry using an air-plus-acetylene flame (Williams et al. 1962). Forage organic matter intake was calculated by dividing fecal organic matter output by the in vitro organic matter indigestibility of esophageal extrusa after subtracting the indigestible contribution of the supplement (IVOMD, Table 2) from fecal output.

Undegraded intake protein of extrusa samples was determined as described by Mass et al. (1996) with the following modifications. Briefly, 1.25 g samples were placed in dacron bags[2] and incubated in a ruminally cannulated steer fed a smooth bromegrass hay (8% crude protein) at 1.8% of body weight. Samples were incubated for 2, 12, and 96 hours. Three separate incubation runs were performed in the same animal. Bags were washed according to Wilkerson et al. (1995) and subjected to analysis of neutral detergent fiber nitrogen. Amounts of neutral detergent fiber nitrogen remaining after incubation were natural log transformed and a rate of degradation was calculated. Undegraded intake protein was calculated using the following formula: UIP = B X $(k_p/(k_d+k_p))$ + C; where B is the pool size or potential undegraded intake protein calculated from the intercept of the natural log transformation of degradation, k_p is the rate of passage and k_d is the rate of degradation of neutral detergent fiber nitrogen, and C is the undegradable fraction (Broderick 1994). Passage rates were determined in a sepa-

[1]Captec Chrome manufactured by Captec Pty. Ltd., Australia, distributed internationally by Nufarm Limited, Manu Street, P.O. Box 22-407, Otahunu, Auckland 6, New Zealand.

[2]Ankom, Inc., Fairport, N.Y.

Table 3. Crude protein (CP), undegraded intake protein (UIP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and in vitro organic matter digestibility (IVOMD)of diet samples collected from cows and calves grazing subirrigated meadow regrowth in 1995 and 1996.

		% of Organic Matter				
Date	Type	CP	UIP	NDF	ADF	IVOMD
27 Oct. 1995	Cow	10.0	1.94	84.4	57.2	53.1
27 Oct. 1995	Calf	10.9	2.45	83.9	55.9	50.1
3 Nov. 1995	Calf	11.5	2.21	76.3	53.0	56.1
15 Oct. 1996	Cow	11.1	1.78	68.0	53.2	46.5
16 Oct. 1996[1]	Calf	13.7	2.91	76.9	63.0	50.6

Mean of samples collected 15 and 16 October.

rate research project at the Gudmundsen Sandhills Laboratory during the 1994 growing season (Lamb 1996). Undegraded intake protein of the supplement fed in this study was determined using the ammonia release procedure of Britton et al. (1978).

Data were analyzed using the MIXED procedures of SAS (1990) with a 2 x 2 factorial treatment design. Sex and year served as blocking factors. Individual calf served as the experimental unit. For weight and weight gain data, year X weaning X supplementation X sex was considered random and was used to test year, supplementation, weaning, sex, supplementation X weaning, sex X weaning, sex X supplementation, and weaning X supplementation X sex. When no significant (P > 0.15) interactions were detected, data were pooled and only main effects presented. For intake data, year X weaning X supplementation was considered random and was used to test year, weaning, supplementation, and weaning X supplementation. Because only steer calves were used to measure intake, sex was not included as a variable when intake data were analyzed.

Results and Discussion

Year effects were significant for initial weight (P = 0.06) and average daily gain (P = 0.04, respectively). Initial weights averaged 217 and 193 kg in 1995 and 1996, respectively, and were greater in 1995 because the trial was started later than anticipated due to the difficulties in getting calves to consume supplements. Daily gains averaged 0.69 and 0.85 kg day^{-1} in 1995 and 1996, respectively, and again were likely influenced by the starting date of the trial.

Calves and cows selected diets that were similar in quality (Table 3). Diets collected with ruminally cannulated calves averaged 12.5% crude protein and 54.8% in vitro organic matter digestibility (Table 3). Lamb et al. (1997) reported similar values to our crude protein but higher in vitro organic matter digestibility for diets collected from esophageally cannulated cows grazing meadow regrowth during the fall. In addition, Lamb et al. (1997) reported similar gains by nursing and weaned calves grazing meadow regrowth. Based on in vitro organic matter digestibility of diet samples reported by Lamb et al. (1997) and the diet data reported here (Table 3), gains would be expected to be lower because our in vitro organic matter digestibilities are lower than those reported by Lamb et al. (1997). Calves selected diets that averaged 2.6% undegraded intake protein, whereas cows grazing meadow regrowth selected diets averaging 1.9% undegraded intake protein (Table 3). Hollingsworth-Jenkins (1994) reported that calves grazing native range selected diets higher in crude protein and undegraded intake protein and similar in digestibility compared to cows grazing the same pastures.

No supplementation by weaning management interactions were detected for initial weight, final weight, or average daily gain (P = 0.83, 0.75, 0.92, respectively). No supplementation by weaning management interactions were detected for forage intake, total intake, forage intake as a percentage of body weight, or total intake as a percentage of body weight (P = 0.18, 0.81, 0.18, 0.94, respectively). Therefore, only main effects will be presented and discussed.

Nursing calves had greater average daily gains and heavier final weights (P = 0.001) than weaned calves (Table 4). These findings agree with those of Lamb et al. (1997) for weaned and nursing spring-born calves grazing subirrigated meadows. Lusby et al. (1981) found that early weaned calves had similar weight gains to calves weaned at 7 months; however, early weaned calves were managed in drylot and fed a concentrate diet rather than consuming a grazed diet. When early weaned calves were managed on pasture with a creep feed, gains were 20 kg lower than nursing calves (Lusby et al. 1981). Sowell et al. (1996) found that calves restricted from suckling the cow's rear udder for 4 weeks had lower weight gains than calves that were not restricted.

Milk represents an important source of nutrients for the growing calf, as represented by the magnitude of the response in

Table 4. Effect of weaning and undegraded intake protein (UIP) supplementation on initial weight, final weight, average daily gains (ADG), forage intake (kg day^{-1}), total intake (kg day^{-1}), forage intake (kg/100 kg body weight), and total intake (kg/100 kg body weight) of calves grazing subirrigated meadow regrowth.

	Main Effects[1]						
	Weaning Management			UIP Supplementation			
	Weaned	Nursing	P-value	Non-Suppl.	Supplemented	P value	SEM[2]
Initial weight (kg)	196.3	213.8	.2072	207.6	202.5	.7560	7.49
Final weight (kg)	222.6	258.6	.0099	238.2	243.0	.6847	8.29
ADG (kg day^{-1})	0.59	0.95	.0009	0.66	0.88	.0306	.046
Forage intake (kg day^{-1})	2.96	2.36	.0090	2.73	2.59	.3257	.093
Total intake (forage + Supplement, kg day^{-1})	3.41	2.61	.0040	2.73	3.30	.0111	.092
Forage intake (kg/100 kg body weight)	1.29	0.89	.0074	1.17	1.02	.0927	.040
Total intake (forage + supplement, kg/100 kg body weight)	1.48	0.99	.0048	1.17	1.30	.1388	.037

[1]All supplement by weaning management interactions were nonsignificant P > 0.15. Data pooled over 2 years.
[2]SEM = standard error of mean.

daily gain. Nursing calves gained 0.36 kg day^{-1} more than weaned calves. In production systems where calves are sold at weaning, this should result in an increase in gross returns to the producer. The effect of lactation on weight and body condition score changes in the cow were not investigated in this trial. Lamb et al. (1997) reported that lactating cows grazing meadow during the fall maintained body condition, while dry cows gained body condition. This finding has implications for production systems in which cows are wintered on low quality forages, because increases in body condition are not expected when cows graze low quality forages with or without proper supplementation (Villalobos et al. 1997). Thinner cows have greater energy requirements than fatter cows during the winter (Thompson et al. 1983).

Calves receiving undegraded intake protein supplementation had greater (P = 0.03) daily gains than non-supplemented calves (Table 4). Weaned and nursing calves responded to supplemental undegraded intake protein in a similar fashion (e.g., no significant supplementation X weaning management interactions), which indicates the undegraded intake protein was likely limiting for both weaned and nursing calves. McCann et al. (1991) reported that gains by steers grazing wheat-annual ryegrass pastures were increased when supplemental undegraded intake protein (fish meal-dried distillers grains) was provided. ZoBell and Goonewardene (1989) reported that nursing calves that had access to a canola (*Brassica napus* L.)-soybean (*Glycine max* L. Merr.) meal creep while grazing native range had higher weight gains than calves receiving no creep feed. Hollingsworth-Jenkins (1994) found that nursing calves grazing native Sandhills range had increased average daily gains when supplemented with undegraded intake protein (treated soybean meal-feather meal) than calves receiving no supplement or supplemental energy (soyhulls-protected fat). Karges et al. (1992) found that yearling steers grazing native Sandhills range responded in a linear fashion to supplemental undegraded intake protein (treated soybean meal-feather meal).

Forage intake and total intake, when expressed either as a percentage of body weight or as kg/day were greater (P = 0.01) by weaned than by nursing steers (Table 4). Boggs et al. (1980) found that milk intake was negatively correlated with forage intake in nursing calves. Le Du et al. (1976) reported that bottle-fed calves fed low quantities of milk consumed more forage than calves fed high quantities of milk. Lusby et al. (1976) found calves that consumed more milk consumed less forage. Contradictory to these findings, Peischel (1980) found that level of milk intake did not affect forage dry matter intake. Even though weaned calves compensated for lack of milk intake by increasing forage intake, this compensation was not enough to increase weight gains to levels of nursing calves.

Forage intakes we report here appear to be low based on forage quality and cattle performance. Ansotegui et al. (1991) reported fecal outputs for calves grazing native range similar to what we observed (data not shown). External marker methodologies may have contributed to our relatively low estimates of intake (Galyean et al. 1986).

No differences were found in forage intake (kg day^{-1}) between supplemented or non-supplemented steers (P = 0.33) which contradicts results of Cremin et al. (1991), who found that forage intake was negatively correlated with consumption of creep feed. Intake of forage and supplement was greater (P = 0.01) by supplemented than nonsupplemented steers. Forage intake, as a percentage of body weight, tended to be greater (P = 0.09) for nonsupplemented than supplemented steers. Total intake, expressed as a percentage of body weight, tended to be greater (P = 0.14) for supplemented calves.

Milk consumption averaged 5.8 and 6.6 kg milk day^{-1} for supplemented and nonsupplemented calves, respectively, and were not different (P = 0.52). This agrees with the findings of Cremin et al. (1991) who reported that level of creep feed intake did not affect milk intake. Assuming that milk is 3.4% protein (NRC 1996), these milk intakes would supply 197 and 211 g of metabolizable protein, respectively. For the nursing calves not receiving the undegraded intake protein supplement, this represents over 50% of the metabolizable protein supply. However, based on the increased daily gain from supplemental undegraded intake protein, milk may not supply adequate metabolizable protein to meet the requirements of grazing beef calves.

Commonly accepted practices of creep feeding cereal grains to nursing calves may not correct metabolizable protein deficiencies in high quality forages. Creep feeding with small amounts of protein supplements that are high in undegraded intake protein may increase weight gains in nursing and weaned calves grazing high quality forages.

Conclusions

High quality forages, such as subirrigated meadow regrowth, may be limiting in metabolizable protein for growth potential of weaned and suckling calves. Even though milk represents an important source of metabolizable protein, milk intake in late lactation may not be sufficient to support potential growth.

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