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Mariela Lamothe
University of Nebraska-Lincoln

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

Don C. Adams
University of Nebraska-Lincoln, dadams1@unl.edu

Jacqueline A. Musgrave
University of Nebraska-Lincoln, jmusgrave1@unl.edu

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

Microbial Protein Synthesis and Efficiency in Nursing Calves

Mariela Lamothe
Terry Klopfenstein
Don Adams
Jacki Musgrave
Galen Erickson[1]

Synthesis of microbial protein in nursing calves increased as forage intake increased while efficiency of microbial protein synthesis remained constant at approximately 19% of forage digestible organic matter intake.

Summary

Microbial protein synthesis and efficiency were estimated in spring-born nursing calves grazing native range and subirrigated meadow. Forage intake increased from 1.5 lb/day (0.6% BW) in June to 5.9 lb/day (1.2% BW) in September while milk intake decreased over the same period. Microbial protein (MCP) synthesis increased from 67 g/day in May to 278 g/day right before weaning in September. Urinary allantoin was used as a marker. Efficiency of MCP synthesis was approximately 19% of forage digestible organic matter (OM) intake.

Introduction

The diet of nursing calves is mainly milk and widely believed adequate to meet their nutrient requirements until weaning. However, research conducted at the University of Nebraska (*1994 Beef Cattle Report,* pp 3-5) showed forage intake of nursing calves is the major component of the diet 2 to 3 months before weaning when calves are 4 to 5 months old. Compensation for reduction in milk consumption by increasing forage intake should result in more OM fermented in the rumen and, consequently, enhanced microbial activity. In addition, UIP is the first limiting nutrient in nursing calves grazing native sandhills range, and UIP supplementation increased weight gains of nursing calves grazing subirrigated meadow (*1998 Beef Cattle Report*, pp. 14-16). However, MCP yield was not measured in any of these studies. Having an estimate of MCP supply is important for estimation of amount of UIP necessary to meet MP requirements. Therefore, the objective of this study was to estimate MCP synthesis and efficiency of MCP synthesis in nursing calves grazing native range and subirrigated meadow in the Nebraska Sandhills.

Procedure

The trial was conducted at the Gudmunsen Sandhills Laboratory of the University of Nebraska, near Whitman, Neb. Sixteen cow/calf pairs were assigned to either upland native range or subirrigated meadow. Dams and their calves were allowed to graze their respective sites for two-week periods from May to September. The first week was for adaptation and the second week for sample collection. Urine samples were collected daily on May 22-26, June 19-23, July 17-21, Aug. 14-18, and Sept. 18-22.

Milk intake of calves was estimated by the 16-hour weigh-suckle-weigh technique. The afternoon before estimating milk intake, calves were separated from their dams for 3 hours, then allowed to nurse and again removed for 16 hours. The following morning, calves were weighed, allowed to nurse and weighed immediately when they finished suckling. Daily milk intake was calculated as the difference between the two weights divided by 16 and multiplied by 24. Fecal output of calves was determined by total fecal collection in June, July, August and September. Each calf was fitted with a fecal collection bag. Feces collected were weighed, mixed and subsampled for DM and OM determination. Bags were emptied daily in the morning. Forage diets were collected with four esophageally fistulated cows, and samples were freeze dried, ground and analyzed for DM, OM, IVOMD, CP and UIP. Forage intake was estimated by dividing total fecal output by the indigestibility of the diet.

Approximately 50 ml of urine were taken daily as a spot sample from each calf. Samples were frozen for further analysis of allantoin and creatinine. Creatinine was used as a marker for the estimation of urine output. Urine volumes used to calculate daily excretion of allantoin from spot urine samples were estimated as: BW(lb) 12.1/creatinine concentration (mg/L), where 12.1 represents the mean daily creatinine excretion rate in mg/lb BW/day. Allantoin concentration was measured colorimetrically using a spectrophotometer. The

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ratio of allantoin to creatinine was used to determine MCP supply. Several assumptions were based on the literature for the conversion of allantoin to MCP:

- — Endogenous purine derivative excretion = 0.175 mmol/lb $BW^{.75}$
- — Proportion of allantoin in total purine derivatives = 90%
- — Proportion of absorbed purines excreted in urine = 85%
- — Digestibility of purines in the small intestine = 83%
- — Ratio purine-N:microbial-N = 0.134

Calf body weights were individually measured one week prior to the collection for each monthly collection period. Data were analyzed as repeated measures using the MIXED procedures of SAS.

Results

Table 1 shows the changes in forage chemical composition by month. There was a decline in both digestibility and protein content of the forage from May to September . Calves' body weight (BW) increased from 189 + 7 lb in May to 486 + 11 lb in September and weights did not differ for calves grazing range or meadow. (P > 0.05; Table 2).

Daily consumption of forage increased while fluid milk consumed decreased (Table 2) from May to September. Forage intake of nursing calves grazing meadow or range was not different in June and September; therefore, average forage OM intake was 1.54 lb/day (0.6% BW) and 5.87 lb/day (1.2% of BW) respectively. Calves consumed about 1.32 lb/day more forage when grazing range than meadow in July and August (P < 0.05). A similar trend was observed for digestible forage OM intake. Fluid milk intake was similar for calves grazing meadow and range (P > 0.05) and it decreased linearly from 16.3 lb/day (6.5% BW) in June to 8.1 lb/day (1.7% BW) in September (P <0.001). Therefore, forage already was consumed in a higher percentage on a DM basis, when calves were 3 to 4 months old (1.12

Table 1. Chemical composition of native range and subirrigated meadow diets during the grazing season.

Item	Ash %[a]	IVOMD %[bc]	CP % of DM[d]	UIP % of DM
Range				
May	7.9[ef]	70.5	12.0[e]	2.76[e]
June	8.0[ef]	66.2	9.7[f]	2.59[e]
July	8.1[ef]	64.0	9.6[f]	2.08[f]
August	7.9[e]	59.5	9.3[f]	2.30[ef]
September	9.2[f]	56.9	9.3[f]	2.45[ef]
Meadow				
May	8.9[e]	73.2	13.7[e]	2.53[f]
June	10.3[e]	70.8	12.1[f]	3.18[e]
July	12.1[f]	63.5	12.7[f]	2.47[f]
August	12.5[f]	61.5	12.3[f]	2.39[f]
September	14.9[g]	56.8	8.5[g]	1.61[g]

[a]Meadow higher than range in July, August and September (P < 0.05).
[b]Meadow higher than range in May and June (P < 0.05).
[c]Linear effect within a column and forage (P < 0.05).
[d]Meadow higher than range in June, July and August (P <0.05).
[e,f,g]Means with unlike superscripts differ within a column and forage (P < 0.05).

Table 2. Fluid milk and forage intake for nursing calves grazing meadow and range during the summer

Item	Body weight lb[a]	Forage OM intake lb/day[b]	Forage OM intake % BW[b]	Fluid milk intake lb/day[a]	Fluid milk intake % BW[a]
Range					
May	189	—	—	—	—
June	249	1.67[c]	0.68[c]	15.8	6.4
July	319	3.54[d]	1.12[d]	14.3	4.5
August	400	4.90[e]	1.24[d]	10.1	2.4
September	486	5.85[f]	1.21[d]	8.8	1.8
Meadow					
May	189	—	—	—	—
June	257	1.41[c]	0.54[d]	16.5	6.6
July	323	2.24[d]	0.69[cd]	16.1	5.0
August	394	3.61[e]	0.91[d]	15.2	3.9
September	486	5.87[f]	1.21[e]	7.3	1.5

[a]Time linear effect (P < 0.001)
[b]Range higher than meadow in July and August (P < 0.05)
[c,d,e,f]Means with unlike superscripts differ within a column and forage (P < 0.05)

Table 3. Urine volume and urinary purine derivatives for nursing calves grazing meadow and range during the summer

Item	Allantoin mmol/L[a]	Urine volume L/day[b]	Allantoin:Creatinine ratio[c]
Range			
May	5.9	8.5	1.22
June	5.7	9.5	1.24
July	6.8	12.4	1.45
August	7.3	12.5	1.30
September	16.0	10.3	1.58
Meadow			
May	2.5	12.7	0.99
June	3.5	14.9	1.06
July	3.0	23.9	1.18
August	5.3	22.1	1.32
September	9.5	16.0	1.51

[a]Range higher than meadow (P < 0.01); Time quadratic effect (P < 0.001).
[b]Meadow higher than Range (P < 0.01); Time quadratic effect (P < 0.01).
[c]Time linear effect (P < 0.001).

Table 4. Digestible forage OM intake (FOMI), microbial protein (MCP) synthesis and efficiency for nursing calves grazing range and meadow during the summer.

Item	Digestible FOMI lb/day[a]	MCP g/day[b]	MCP Efficiency %
Range			
May	—	73	—
June	1.10[c]	99	20.1
July	2.27[d]	179	18.7
August	2.93[e]	189	14.2
September	3.32[f]	290	19.3
Meadow			
May	—	60	—
June	0.99[c]	85	20.5
July	1.43[c]	133	21.1
August	2.22[d]	189	19.5
September	3.34[e]	265	17.6

[a]Range higher than meadow in July and August ($P < 0.05$).
[b]Time quadratic effect ($P < 0.05$).
[c,d,e,f]Means with unlike superscripts differ within a column and forage ($P < 0.05$).

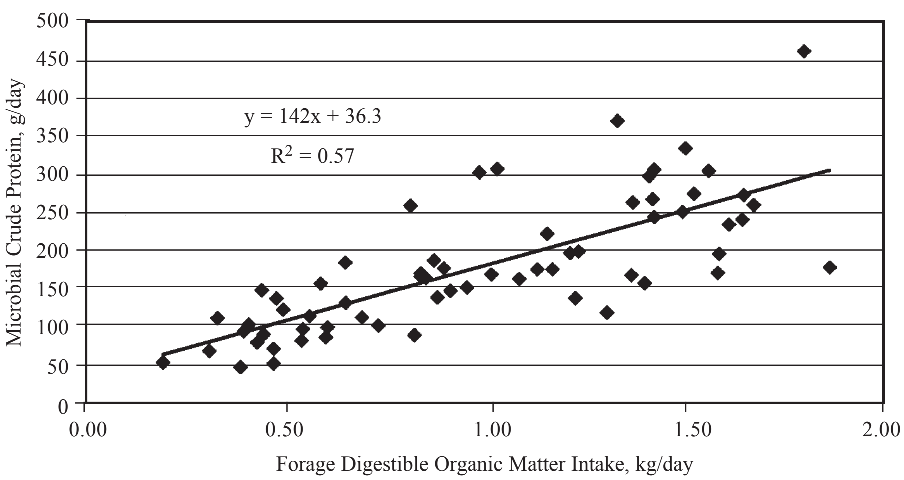

Figure 1. Relationship of forage digestible organic matter intake of nursing calves to microbial crude protein production.

and 0.69% of BW for July range and meadow respectively than milk, 0.57% BW. The increasing contribution of forage in the diet brings along a higher rumen microbial activity indicated by increasing allantoin output (Table 3) and MCP synthesis (Table 4). MCP yield did not differ between meadow and range forage ($P > 0.05$), and it increased from 67 g/day in May to 278 g/day before weaning in September ($P < 0.001$).

The increase in both forage intake and MCP yield resulted in a fairly constant MCP efficiency, being approximately 19% of digestible forage OM intake ($P > 0.05$; Table 4). Previous studies suggest calves select forage of higher digestibility and CP content than cows (*1994 Beef Cattle Report,* pp. 3-5). Because diets were collected with mature cows, MCP efficiency might be slightly overestimated in this trial.

Another way to analyze microbial efficiency is to regress microbial crude protein synthesized against the intake of forage digestible organic matter. This was accomplished by using observations from all 16 calves across the four monthly collection periods (Figure 1). Both MCP and FDOMI increased as the season progressed. The relationship ($r^2 = .57$) between MCP and FDOMI was quite good and would be expected because the FDOMI is the source of energy for the microorganisms. Because of esphogeal groove closure milk bypasses the rumen.

The slope of the regression of MCP on FDOMI was 142 grams MCP per kilogram of FDOMI. This would be a microbial efficiency of 14.2% which is closer to NRC estimates. The intercept was 36.3 (not zero) indicating that there may be a systematic error in the assumptions used in calculating MCP from allantoin in spot urine samples.

An estimate of the amount of MCP or efficiency of MCP production helps to predict DIP requirements more accurately as well as the contribution of MCP to total MP supply. In this trial, MCP represented approximately 21% of total MP in June increasing to 55.5% ,while milk represented 30% of MP, in September. This has implications when formulating supplements or forage strategies to meet MP requirements.

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[1]Mariela Lamothe, graduate student; Terry Klopfenstein, professor, Galen Erickson, assistant professor, Animal Science, Lincoln; Don Adams, professor, J. Musgrave, research technician, West Central Research and Extension Center, North Platte.