

CHANGES IN RUMEN CAPACITY OF DAIRY COWS DURING THE PERIPARTURIENT PERIOD

A. F. Park, J. E. Shirley, J. M. DeFrain, E. C. Titgemeyer, E. E. Ferdinand, R. C. Cochran, D. G. Schmidt, S. E. Ives, and T. G. Nagaraja¹

Summary

Four-ru minally fistulated, multiparous, pregnant Holstein cows were studied to characterize ruminal adaptations during the transition from gestation to lactation. Cows were fed typical far-off and close-up diets, a late lactation diet containing wet corn gluten feed (20% DM), and an alfalfa hay, corn silage based early lactation diet. Ruminal measurements were obtained 72 (late lactation), 51 (far-off dry), 23 and 9 (close-up dry) days before expected parturition and 6, 20, and 34 days postpartum. Measurements included total fill, dry matter fill, fluid fill, and water-holding capacity of the rumen. Dry matter intake and milk production data were collected daily and body weight and body condition were determined weekly. Body weights and condition increased during the dry period, whereas intake as a percentage of body weight decreased. Ruminal water holding capacity, an indicator of rumen capacity, increased linearly from late lactation to 34 days postpartum. These data suggest rumen capacity is not the causative factor of intake depression in dairy cows during the final 3 wk of gestation.

(Key Words: Rumen Capacity, Dairy, Periparturient.)

Introduction

Dry matter intake generally decreases by 20 to 30% in dairy cows during the last 3 wk before parturition. This decrease in intake coincides with increasing fetoplacental weight and is thought to be partly due to a

decrease in rumen capacity because of space limitations in the abdominal cavity. Physical measurements of the space available in the abdominal cavity obtained from frozen cross sections of pregnant and nonpregnant cows indicated a decrease of 30% due to the presence of the fetus, placenta, and associated fluids. The problem with this technique is that it does not account for the expandability of the abdominal cavity or repositioning of the uterus. The purpose of our study was to measure changes in rumen capacity and function in vivo during late gestation and early lactation in Holstein cows in order to determine if the observed decrease in dry matter intake is associated with decreased rumen capacity.

Procedures

Four-ru minally fistulated, multiparous, pregnant Holstein cows were utilized in this study. The cows were impregnated to sires of similar calving ease and had similar projected calving dates, body weights, body condition scores, previous 305-day mature equivalent milk yields, and frame sizes (Table 1). Frame size was defined using hip and wither height as well as width between the hooks. Cows were housed in a tie-stall barn during an experiment that was initiated 94 days before calving and terminated 34 days after calving. Cows were fed typical late lactation, far-off, close-up, and early lactation diets (Table 2). Daily feed intakes and milk weights were recorded for individual cows. Body weights and condition scores were determined weekly.

¹Department of Diagnostic Medicine and Pathobiology.

Ruminal total fill, dry matter (DM) fill, liquid fill, and water holding capacity were determined on days 72 (late lactation), 51 (far-off dry), 23 and 9 (close-up dry) prepartum and 6, 20, and 34 days postpartum. Ruminal water holding capacity was defined as the weight of water removed from a rumen filled with water to a pre-set mark on an air outlet hose and was assumed to estimate rumen capacity. The pre-set mark on the air outlet hose was aligned with the topline of the cow. Liquid fill represents the difference between total fill and DM fill. On sample days, rumens were emptied, contents weighed, and sampled in triplicate for dry matter determination. Rumens were then rinsed and filled with water to a pre-set mark on an air outlet hose. At this point the scales were zeroed and the water removed from the rumen was weighed.

Results and Discussion

The initial characteristics of the study cows are presented in Table 1. Cows of similar size, condition, bodyweight, and milk production potential were selected to reduce variation in the pre-determined measurements. The cows were impregnated to sires of similar calving ease scores ($9.8 \pm 0.2\%$) and projected calving dates (± 4 days). The average birth weight of the calves was 80.8 ± 10.3 lb and the cows calved between December 21 and 29, 2000. None of the cows experienced health disorders during the experimental period and milk yield reached 88 lb by day 34 of lactation. All cows were offered a common total mixed ration (TMR) consistent with their state of lactation or gestation (Tables 2 and 3).

The cows gained approximately 132 lb of body weight and their BCS increased from 2.43 ± 0.21 to 2.94 ± 0.21 between days 72 and 9 prepartum. Dry matter intake expressed as a percentage of body weight (Figure 1) decreased during this time but nutrient intake was sufficient to support fetal growth and improve nutritional status as evidenced by the increase in body weight and condition score. Ruminal dry matter fill exhibited the same pattern as dry matter intake on a percentage of body weight basis.

Table 1. Initial Characteristics of Animals

Item	Mean	SE
BCS	2.63	0.16
BW, lb	1341.0	181.0
305-2X-ME milk, lb	23084.0	1244.0
Parity	2.0	0.0
Hook to hook, inch	22.1	2.0
Hip height, inch	55.1	0.8
Wither height, in.	54.3	0.9

Rumen water holding capacity increased linearly ($P < 0.01$) from late lactation to early lactation (Figure 2), which clearly refutes the theory that the observed decrease in dry matter intake prepartum is due to a decrease in rumen capacity. These results indicate that the expandability of the abdominal cavity is sufficient to accommodate the developing fetus without unduly restricting rumen capacity.

Evidence that rumen capacity does not restrict intake is further supported by the fact that ruminal dry matter fill expressed as a percentage of rumen water holding capacity decreases prepartum and increases postpartum (Figure 3). Dietary neutral detergent fiber (NDF) content has been advanced as a regulator of dry matter intake. Our results do not support this concept because NDF intake expressed as a percentage of rumen water holding capacity increased when cows consumed the high NDF far-off diet, whereas dry matter intake decreased (Figure 4). Intake of NDF mimicked DMI when cows consumed the close-up and lactation diets. In summary, the depression in dry matter intake observed prepartum is not due to limited rumen capacity.

Table 2. Experimental Diets

Item	Diets (% of DM)			
	Late Lact.	Far-off	Close-up	Early Lact.
Alfalfa hay	20.0	0.0	15.0	30.0
Prairie hay	0.0	48.4	20.0	0.0
Corn silage	10.1	19.8	30.0	15.0
Corn grain	27.7	22.4	18.7	32.0
Whole cottonseed	9.3	0.0	0.0	9.3
Fishmeal	1.3	0.0	0.0	1.3
Expeller soybean meal	7.7	0.0	9.4	3.3
48% soybean meal	0.0	8.4	4.4	4.4
Wet corn gluten feed	19.6	0.0	0.0	0.0
Molasses	1.3	0.0	0.0	1.0
Limestone	1.38	0.06	0.60	1.36
Dicalcium phosphate	0.05	0.40	0.74	0.88
Sodium bicarbonate	0.68	0.00	0.00	0.75
Trace mineral salt ¹	0.29	0.34	0.50	0.32
Magnesium oxide	0.20	0.00	0.50	0.21
Vitamin A,D, E ²	0.12	0.11	0.12	0.13
Sodium selenite premix ³	0.08	0.02	0.04	0.01

¹Composition: not less than 95.5% NaCl, 0.24% Mn, 0.24% Fe, 0.05% Mg, 0.032% Cu, 0.032% Zn, 0.007% I, and 0.004% Co.

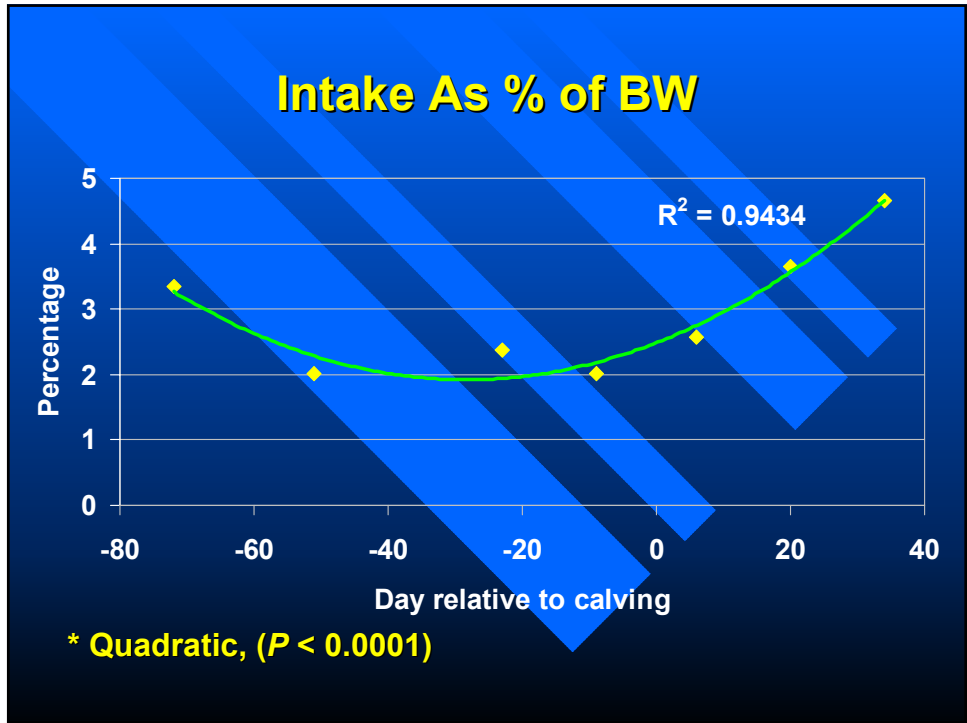
²Contributed 4912 IU vitamin A, 2358 IU vitamin D, and 24 IU vitamin E per kg diet DM.

³Contributed 0.06 mg Se per kg diet DM.

Table 3. Chemical Characteristics of Experimental Diets

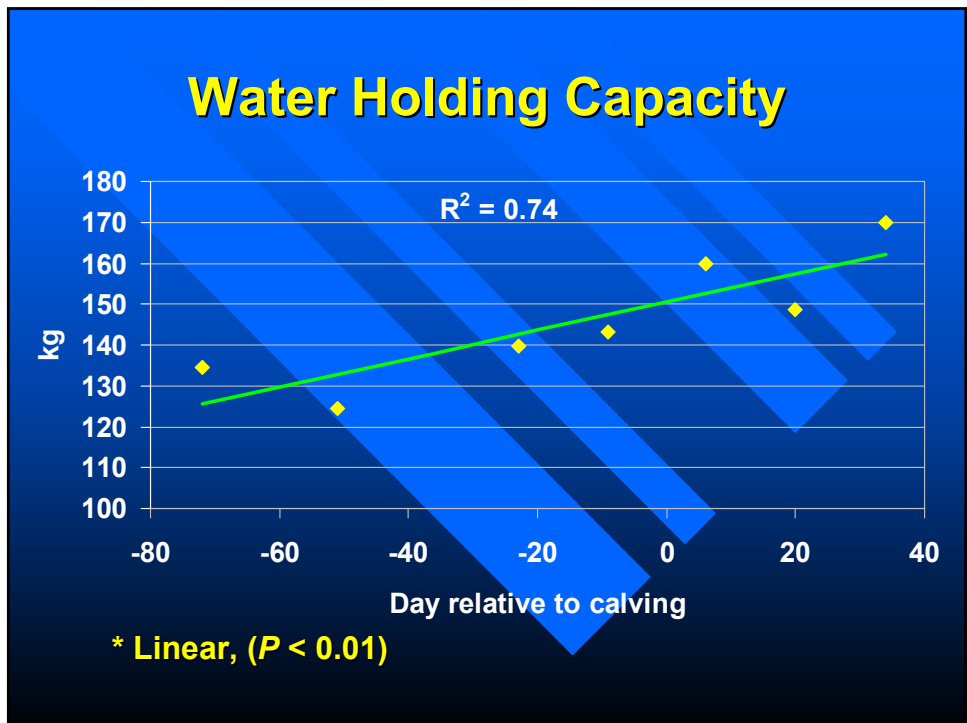
Item	Diets			
	Late Lact.	Far-off	Close-up	Lactation
Dry matter, %	75.25	82.46	76.87	82.50
Crude protein, %	18.68	11.47	15.57	18.38
Soluble protein, %	31.31	25.18	25.18	31.32
RDP, % of DM ¹	62.09	63.44	65.75	63.37
ADF, %	17.45	25.15	22.01	18.18
NDF, %	29.94	42.88	34.42	26.97
Non-fiber carbohydrate, %	37.84	35.16	39.12	40.44
NE _L , Mcal/kg	1.73	1.46	1.56	1.70
Crude fat, %	5.75	3.76	3.49	5.60
Ash, %	7.70	6.72	7.40	8.43
TDN, %	73.24	67.02	69.08	72.25
Calcium, %	1.07	0.52	0.81	1.51
Phosphorus, %	0.66	0.36	0.49	0.71
Magnesium, %	0.34	0.20	0.35	0.33
Potassium, %	1.41	1.15	1.49	1.48
Sodium, %	0.37	0.11	0.17	0.33
Sulfur, %	0.25	0.13	0.17	0.21

¹Based on feed analysis from Dairy Herd Improvement Forage Testing Laboratory (Ithaca, NY).



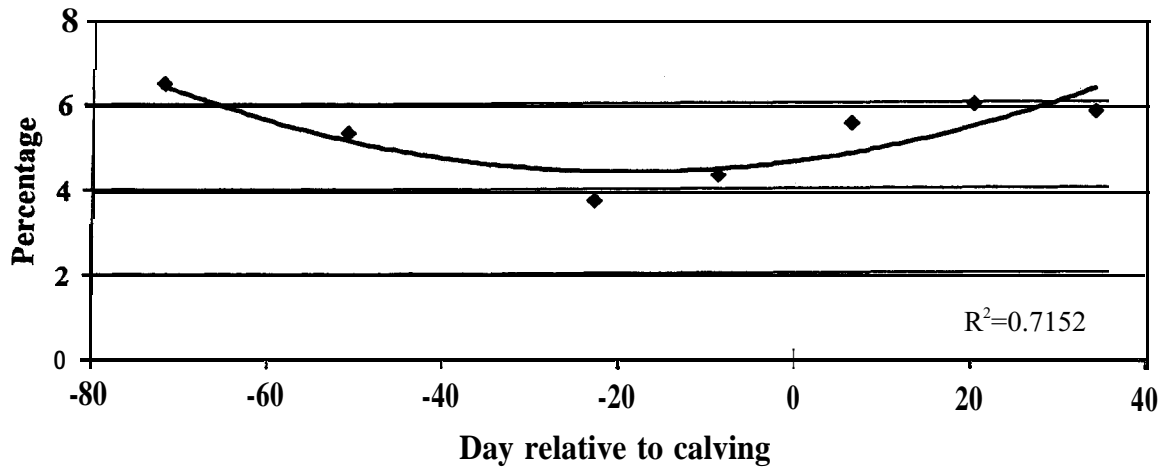
SEM = 0.28.

Figure 1. Dry Matter Intake as a Percentage of Body Weight.



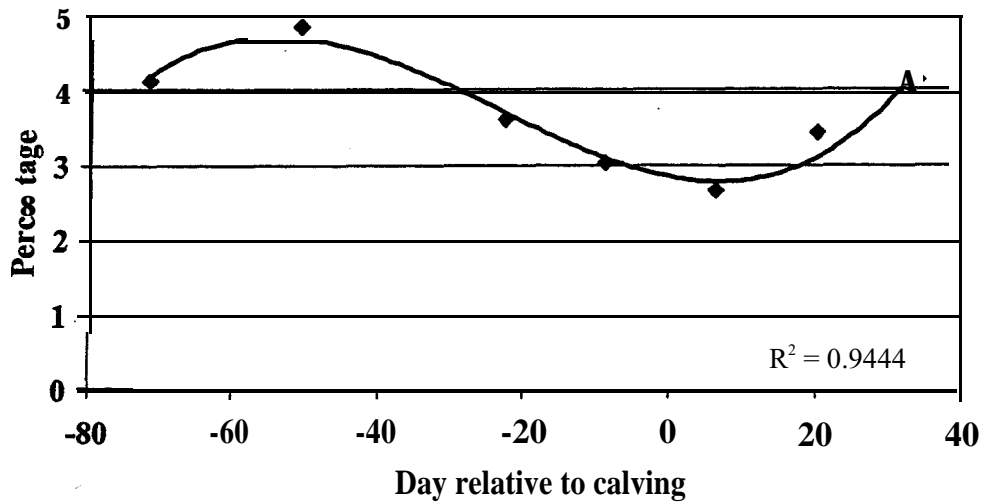
SEM = 10.9.

Figure 2. Rumen Water Holding Capacity.



*Quadratic, $P < 0.01$.
SEM = 3.7.

Figure 3. Dry Matter Fill as a Percentage of Rumen Water Holding Capacity.



*Quadratic, $P < 0.01$
SEM = 0.44.

Figure 4. Neutral Detergent Fiber (NDF) Intake as a Percentage of Water Holding Capacity.