178 Development of a mechanistic model to understand the dynamics of liquid flow out of the reticulo-rumen in dairy cattle. S. Seo*[1], C. Lanzas[1], L. Tedeschi[2], and D. Fox[1], [1]*Cornell University*, *Ithaca, NY*, [2]*Texas A&M University*, *College Station*.

A mechanistic model was developed to investigate the dynamics of liquid flow out of the reticulo-rumen (RR) through the reticulo-omasal orifice (ROO) quantitatively. The model assumes liquid outflow rate (LOFR, kg/h) is a product of frequency of ROO opening, its duration per opening and the amount of liquid passed per opening. Based on published studies, ROO openings were assumed to be coordinated with primary reticular contractions. Two principles of fluid dynamics were applied in estimating the amount of liquid passed per opening, which is a function of area of the orifice, pressure gradient between reticulum and omasum and density of fluid. Pressure gradient was assumed to be the same as amplitude of reticular contraction. A database was built to quantify the relationships between the variables. A random coefficients model was used with the MIXED procedure of SAS with studies as a random variable to identify significant variables. The parameters were estimated using the same procedure only if a random study effect was significant; otherwise the GLM procedure was used. A linear regression model was developed to predict frequency of ROO openings associated with primary reticular contractions during eating, ruminating and resting. Means of database were used for estimating duration and amplitude. Previous studies indicated the ROO opens about 3 seconds at the second phasic primary reticular contraction. However, simulations of our model suggested that ROO should be opened longer for each contraction cycle. Analysis of 15 observations indicated that ROO should have opened 2.36 (± 0.93) times more than the mean values; this value was successfully estimated with a regression equation containing DMI, BW and total digesta in the rumen. With this equation incorporated, the model explained 89% and 83% of variations in 17 observations in an independent database with root mean square prediction errors of 0.80 and 1.17 for LOFR and fractional liquid passage rate (%/h), respectively. We conclude this mechanistic model can be used to increase our understanding of liquid dynamics in the RR.

Key Words: Reticulo-omasal orifice, Ruminal liquid dynamics, Modeling

179 Supplementation of diets with limited methionine content with rumen-protected forms of methionine, choline, and betaine in early lactation Holstein cows. S. Davidson*, B. Hopkins, J. Odle, C. Brownie, V. Fellner, and L. Whitlow, *North Carolina State University*, *Raleigh*.

Eighty lactating Holstein cows from 21 to 91 days in milk were fed a corn silage-based total mixed ration (TMR) formulated to meet National Research Council (2001) recommendations except the Met content was limited (42 g/d) in order to investigate the impact of supplementing rumen-protected (RP) forms of Met, betaine, and choline on performance and metabolism. One of four supplements was blended into the TMR to produce four dietary treatments: 1.) control, 2.) 20 g/d RP-Met, 3.) 45 g/d RP-betaine, and 4.) 40 g/d RP-choline. Calcium salts of fatty acids were used to protect both RP-betaine and RP-choline supplements and were added to both control and RP-Met supplements so that equal amounts of fat were supplied to all treatments. Intake of DM was not different among treatments ($P > 0.2$). The treatment by parity interaction tended to be different ($P = 0.06$) for milk yield with 44.3 kg/d produced in MP cows fed RP-choline compared to MP cows fed all other treatments (37.8, 40.0, and 38.7, respectively) while there were no differences among treatments in PP cows. Cows fed RP-Met or RP-choline had higher milk CP yield than cows fed control or RP-betaine ($P = 0.02$). There were no differences in milk fat yield or milk urea nitrogen (MUN) ($P > 0.2$). Mean body weight and body condition score (BCS) were not different among treatments ($P > 0.2$).

Table 1.

Item	Control	RP-met	RP-bet	RP-chol	SEM	Treatment ($P =$)	Parity ($P =$)
Milk yield, kg/d	32.8[b]	33.9[a,b]	32.3[b]	35.8[a]	0.9	0.04	0.01
Primiparous milk yield, kg/d	27.7	27.5	26.0	27.2	1.3	0.79	-
Multiparous milk yield, kg/d	37.8[b]	40.0[b]	38.7[b]	44.3[a]	1.3	0.01	-
Milk CP, %	2.54[b]	2.69[a]	2.55[b]	2.59[a,b]	0.04	0.05	0.01
Milk CP, kg/d	0.82[b]	0.90[a]	0.83[b]	0.93[a]	0.03	0.02	0.01
Milk fat, %	2.89[a]	2.60[b]	2.98[a]	2.77[a,b]	0.10	0.05	0.04
Milk fat, kg/d	0.93	0.88	0.95	0.98	0.04	0.28	0.01
MUN, mg/dl	17.1	15.8	16.6	16.3	0.6	0.45	0.09
Body weight, kg	525	547	526	547	12	0.34	0.01
BCS	2.22	2.29	2.16	2.14	0.08	0.51	0.58

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

Key Words: Methionine, Choline, Betaine

180 Effect of ruminally degraded protein source on microbial protein flow in Holstein cows. A. B. Peterson*[1], R. L. Baldwin, VI[2], B. J. Bequette[1], and R. A. Kohn[1], [1]*University of Maryland*, *College Park*, [2]*USDA-ARS*, *Beltsville, MD*.

The objective was to evaluate the effect of ruminally degraded protein (**RDP**) source on microbial protein flow measured from the reticulum and duodenum using ^{15}N and estimated from milk, urine and blood using allantoin. Eight early lactation Holstein cows were arranged in a repeated 4x4 Latin square design balanced for carryover effects with 21 d periods. All diets were isoenergetic (1.71 Mcal/kg) and had the same rumen undegraded protein content (5.6%). Cows were fed either a base diet containing 12.8% CP or one of three treatment diets containing 16% CP supplemented with urea, casein or both. Cows were also infused with Cr-mordanted NDF, Co-EDTA and $^{15}NH_4$ as solid passage, liquid passage and microbial protein markers, respectively. Microbial protein flow was lower ($P < 0.05$) for cows fed the base diet than for cows fed the other diets irrespective of which method was used for estimation. Microbial N flow through the duodenum in cows fed the base diet was 237 g/d compared with 292 g/d for cows fed the other three diets. Microbial N leaving the rumen was 227 g/d for cows fed the base diet compared with 322 g/d for the other three treatments. Allantoin concentration, an indicator of microbial protein yield, was lower in milk and plasma for cows fed the base diet (130 and 191 μmol/L) than for cows fed the urea/casein diet (267 and 231 μmol/L, $P < 0.05$). Additionally, allantoin excretion in urine was 81 mmol/d for cows fed the base diet compared with 116 mmol/d for cows fed the urea/casein diet ($P < 0.05$). These results indicate that by using passage markers, reticulum samples can accurately measure flow of microbial protein to the duodenum, and allantoin was a good indicator of microbial protein flow. Additionally, amino acids and non-protein N can be used in equal efficiency for microbial protein production and the amount of RDP in the diet, not the source of RDP, is most important in diet formulation.

Key Words: Rumen degraded protein, Microbial protein, Allantoin

181 Milk replacer composition and nutrient utilization in pre-weaned calves. S. R. Hill*, K. M. Daniels, K. F. Knowlton, R. E. James, R. E. Pearson, and R. M. Akers, *Virginia Polytechnic Institute and State University*, *Blacksburg*.

Twenty-four newborn Holstein heifer calves (n=6) were fed one of four diets: CON (20/20 fed at 450 g/d, 24%CP, 0.53%P); HP (28/20 fed at 970 g/d, 32%CP, 0.55%P); HFHP- (28/28 fed at 970 g/d, 32%CP, 0.46%P); and HFHP+ (28/28 fed at 1460 g/d, 32%CP, 0.46%P). Calves were grouped by age and treatments were assigned randomly within group. Calves were fed 3.4 L of colostrum twice within 16h of birth. Upon arrival at the research farm, calves were fed a 20/20 milk replacer for the first two feedings. On d 3, treatments were imposed and calf starter (20% CP, 0.48%P) comprised of corn (40%), soybean meal (40%) and cottonseed hulls (20%) was offered free choice. Calves were on study for ~63 d. Total collection of feed refusals, feces and urine were initiated on d 59 ± 2d. Body weight and body size measures were taken weekly. Feces, urine, milk replacers, and starter samples were pooled (25% of each daily sample) by calf or diet, respectively, across collection period and analyzed for total Kjeldhal N and total P. All calves were slaughtered at 63 d to evaluate additional tissues (reported elsewhere). Preplanned contrasts were used to compare CON to all, HP to HFHP-, and CON to HFHP-. Total DMI was not different as calves fed CON consumed more starter than those fed greater amounts of milk replacer. Apparent DMD was lower for calves fed CON. Fecal output (kg DM/d) and fecal N excretion were highest in calves fed CON while urine output (kg/d) and urine N excretion were lowest. Nitrogen intake and urine N excretion were highest for calves fed HFHP+ but were not affected by fat content (HFHP- vs. HP). Nitrogen retention was not improved by increasing energy intake (mean = 34.9%), however, it was improved by increasing N intake (CON vs. HP; 20.5 vs. 38.2%). Phosphorus digestibility, total excretion, partitioning, and retention were not impacted by treatment. Calves fed HP tended to have higher P retention compared to those fed CON. Milk replacer composition influenced nutrient excretion in pre-weaned calves.

Key Words: Calf, Milk replacer, Nutrient excretion

182 Use of infrared thermography to non-invasively identify lesions in dairy cows. B. A. Munsell*[1], D. K. Beede[1], J. J. Domecq[1], W. B. Epperson[2], A. Ragavendran[1], N. T. Wright[1], and A. J. Zanella[1], [1]*Michigan State University*, *East Lansing*, [2]*Ohio State University*, *Columbus*.

Infrared thermography (IRT) creates a pictorial representation of the surface temperature of an object. It has potential to detect inflammation associated with lameness. In the dairy industry, lameness is a costly problem and currently few methods are available for early lameness detection. In this study, IRT was used to assess the surface temperature of the coronary band region of the hind limbs of dairy cows. On day 1 of the 11 day collection period, 30 multiparous Holstein cows less than 40 DIM were selected based on their locomotion score (LS): 15 sound LS 1 cows and 15 moderately lame LS 3 cows (Sprecher et al., Theriogenology:43, 1997). IRT images and locomotion scores were collected once daily after the second of 3 milkings for 11 consecutive days. On d 6, claws of all cows were trimmed to identify lesions. Sixteen cows had 1 or more lesions; 9 cows with an average LS of 2 (mildly lame) or greater and 7 cows with an average LS of less than 2 over the 5 d prior to hoof trimming had at least 1 lesion. Three different image views were analyzed for each hind limb: dorsal, lateral and plantar aspects of the coronary band. Images were analyzed using ThermaCAM Reporter 7.0 (FLIR Systems, Inc., Boston, MA). Average and maximum temperatures (max temps) were identified from within an area approximately 2 cm above to 2 cm below the coronary band. Max temps were correlated with average temperatures ($r = 0.88$, $P < 0.01$) and max temp values were used in all statistical analyses. Data were analyzed using the PROC MIXED procedure of SAS with view, limb, lesion, pre and post trimming as fixed effects. Variability due to cows, view and limb were modeled using appropriate covariance structures. There was a significant difference ($P<0.05$) in max temp among the three views. Cows with lesions had a higher max temp of the coronary band in the lateral view than cows without lesions over the 5 d prior to trimming ($P<0.05$; 33.7 ± 0.16 and 33.0 ± 0.18°C respectively). There was no significant difference in max temp between lesion and non-lesion cows over the 5 d post trimming. These results suggest that IRT may be useful to distinguish cows that have claw lesions.

Key Words: Infrared thermography, Lameness

183 Effect of feeding soybean and linseed oils as whey protein gel composites, calcium salts or free oil on rumen fermentation, digestibility and duodenal flow of fatty acids. S. O. Juchem*, J. M. Heguy, E. J. DePeters, J. E. P. Santos, M. Rosenberg, and S. J. Taylor, *University of California*, *Davis*.

Different methods exist to reduce rumen biohydrogenation of dietary polyunsaturated fatty acids (PUFA), but responses in flow of PUFA to the small intestine have been inconsistent. A novel gel composed by whey protein, water, and oil (U.S. Patent Application 20040058003 A1 [Pending]; U.S. Patent Application 20050089550 A1 [Pending]) was developed. The objective was to compare the efficacy of feeding PUFA in different chemical forms on rumen fermentation, nutrient digestibility in the rumen and postrumen, and flow of PUFA to the duodenum. The supplemental fatty acid (FA) source was a 1:1 (w:w) mixture of soybean:linseed oils (S/L) from which the three supplements were manufactured. Four primiparous Holstein cows were used in a 4x4 Latin square with 14 d periods. Cows were surgically fitted with cannulas in the rumen and duodenum. The S/L was included in the diet as (1) unmodified oil (O; 1.9%), (2) calcium salts (CaS; 2.2%), (3) whey protein concentrate (WPC; 2.6%) gel composite or (4) whey protein isolate (WPI; 2.8% of DM) gel composite. Gel composites were hand-mixed in the TMR twice daily, while O and CaS were part of the TMR. Diets were formulated to provide similar amounts of FA. Data were analyzed by the MIXED procedure of SAS and repeated measures were utilized for variables that contained a time component. Dry matter intake and production traits were not affected. Rumen pH (6.41, 6.51, 6.41 and 6.45) was unaffected by treatments. Molar concentrations of total VFA (117, 107, 113 and 113 mM/L) were similar across diets, for O, CaS, WPC and WPI, respectively, as well as acetate, propionate and butyrate concentrations. Changes in body weight (7.3, -0.12, 7.1 and -2.1 kg) and BCS were not affected. Feeding WPI increased the flow of C18:2 and C18:3 (g/d) to the duodenum compared to the other treatments.

Key Words: Whey protein gel, Biohydrogenation, Unsaturated