As placental growth and vascularity precedes exponential fetal growth, not only is proper establishment of the placenta important, but a continual plasticity of placental function throughout gestation. Inadequate maternal environment has been documented to alter fetal organogenesis and growth, thus leading to improper postnatal growth and performance in many livestock species. The timing and duration of maternal nutritional restriction appears to influence the capillary vascularity, angiogenic profile, and vascular function of the placenta in cattle and sheep. Moreover, upon realimentation, it appears as if the placenta may try to “overcompensate” allowing for enhanced blood flow and nutrient delivery. In environments where fetal growth and/or fetal organogenesis are compromised, potential therapeutics may augment placental nutrient transport capacity and improve offspring performance. Supplementation of specific nutrients, including selenium and protein, as well as hormone supplements, such as indolamines during times of nutrient restriction may assist placental function. Current use of Doppler ultrasonography has allowed for repeated measurements of uterine and umbilical blood flow including assessment of uteroplacental hemodynamics in cattle and sheep. Moreover, these variables can be monitored in conjunction with placental capacity and fetal growth at specific time points of gestation. Elucidating the consequences of inadequate maternal intake on the continual plasticity of placental function will allow us to determine the proper timing and duration for intervention.

**Key words:** metabolites, hormones, markers of body reserve status

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**Metabolic gene expression in bovine ruminal tissue in response to age and pre and postweaning plane of nutrition.** A. Naen*, J. Stamey, J. K. Drackley, and J. J. Looft, University of Illinois, Urbana.

We evaluated expression of 22 genes encoding enzymes involved in ketogenesis, cholesterogenesis, TCA cycle flux, long-chain fatty acid (LCFA) oxidation, and transcriptional regulation in ruminal tissue of male Holstein calves fed a conventional milk replacer (20% CP, 20% fat; 1.25% of birth BW as solids) and starter (19.6% CP, DM basis; control) or enhanced milk replacer (28.5% CP, 15% fat; 2% of BW; ENH) and enhanced starter (25.5% CP, DM basis). All calves were weaned on d 42. Groups of calves in control and ENH were harvested after 43 d (wk 5) and 71 d (wk 10) of feeding. There was marked upregulation of HMGCS2, the rate-limiting enzyme of hepatic mitochondrial ketogenesis in non-ruminants, between wk 5 and 10 regardless of diet. This response paralleled an increase in plasma BHBA concentration (0.09 vs. 0.24 mmol/L) between wk 5 and 10. Expression of other ketogenic (BDH1, HMGCL), cholesterogenic (HMGCS1), and TCA cycle-related enzymes (LDHA, GOT2, PCCA) also increased by wk 10 regardless of diet. A higher expression of CPT1A and ACADVL at wk 5 in calves fed ENH vs. control suggested greater LCFA oxidation potentially driven by the greater intake of LCFA from milk replacer. This suggestion is supported by the greater concentration of plasma NEFA (128 vs. 95 μEq/L) at wk 5 due to ENH vs. control. Expression of peroxisome proliferator-activated receptor-δ increased ~8-fold between wk 5 and 10 regardless of diet, suggesting a role for this nuclear receptor in postweaning ruminal tissue development. In conclusion, several metabolic enzymes were upregulated at wk 10 regardless of diet suggesting a coordinated response to support ruminal tissue development. The mRNA of HMGCS2 accounted for ca. 50% of total genes measured (e.g., HMGCS1 was 0.2%), suggesting this enzyme is key for regulating ketogenesis in ruminal epithelium as in liver. Enhanced nutrition during the first 5 wk of life had minor effects on the selected genes.

**Key words:** ketogenesis, nuclear receptor, dairy calf
400 Effects of plane of nutrition and 2,4-thiazolidinedione on insulin responses and adipose tissue gene expression in dairy cattle during late gestation. K. M. Schoenberg* and T. R. Overton, Cornell University, Ithaca, NY.

The objective was to determine effects of an insulin–sensitizing agent (thiazolidinedione, TZD) and dietary energy level on glucose and fatty acid metabolism during late gestation. Multiparous Holstein cows (n = 32) 50 d before expected calving date were assigned to 1 of 2 dietary energy levels for 3 wks (High, 1.52 Mcal/kg NEL; or Low, 1.34 Mcal/kg NEL) and received daily 4.0 mg TZD/kg BW (TZD) or Saline i.v. for the final 2 wk. Cows administered TZD had higher plasma glucose (62.5 ± 59.6 mg/dL; P = 0.03) than Saline cows and cows fed the High diet had higher plasma insulin (35.1 ± 25.3 μIU/mL; P = 0.03) compared with those fed the Low diet. All cows were subjected to an i.v. glucose tolerance test (GTT; 0.25 g dextrose/kg BW) and an insulin challenge (IC; 1.0 μg/kg BW) 110 min later. High cows tended to have a lower area under the curve (AUC) for plasma glucose during GTT (1895 vs. 2410 mg/dLx90 min; P = 0.13) than Low cows; however, Low cows had more negative NEFA AUC (−23.4 vs. −12.1 mg/dLx15 min; P = 0.08) than Saline, suggesting that TZD–treated cows had greater responses to insulin. Interactions of diet and TZD were only significant (P = 0.04) for NEFA responses to IC such that Low cows receiving TZD had a negative AUC (−80 μEq/Lx15 min), cows fed the High diet and treated with either saline or TZD had slightly positive AUC (65 and 67 μEq/Lx15 min, respectively), and cows fed the Low diet receiving Saline had the most positive AUC (517 μEq/Lx15 min). Cows fed the High diet had greater lipoprotein lipase mRNA expression (2.2 vs. 1.6; P = 0.10) and peroxisome proliferator–activated receptor–γ expression (2.4 vs. 1.3; P = 0.02) in adipose tissue collected by biopsy at the end of the study. These results indicate that energy level and insulin–sensitizing agents affect glucose and lipid metabolism during the dry period.

Key words: cattle, immune, stress
Effects of overstocking on glucocorticoid production and analyses associated with energy metabolism. J. M. Huzzey*1, D. V. Nydam1, R. J. Grant2, and T. R. Overton1, 1Cornell University, Ithaca, NY, 2W. H. Miner Institute, Chazy, NY.

The objective of this study was to determine if overstocking alters energy metabolism and glucocorticoid production. Four groups of 10 dry Holstein cows (~60 d prepartum) were exposed to 2 treatments: Control (1 lying stall/cow and 0.67 m linear feed bunk (FB) space/cow) and Overstocked (0.5 stalls/cow and 0.34 m FB/cow) in a replicated 2 × 2 crossover design with 14-d treatments. Plasma NEFA, glucose and insulin were measured from blood sampled every 2 d of each treatment and during an intravenous glucose tolerance test (GTT: 0.25 g dextrose/kg BW) performed on d 13. Feces, collected every 2 d, were analyzed for fecal cortisol metabolites (FCORT). Plasma cortisol response to an intravenous ACTH challenge (0.125 IU ACTH/kg BW) was measured on d 14. Data from individual cows were averaged to create a group mean and all statistical analyses used group as the experimental unit. Average DMI per cow was greater during the overstocked treatment relative to the control period (15.9 vs. 14.9 kg/d, P < 0.001). NEFA and glucose concentrations were higher during the overstocked treatment (0.11 vs. 0.09 mEq/L and 65 vs. 64 mg/dl respectively, P < 0.05); however, when stratified by parity these responses were limited to heifers (P < 0.01). Overstocking had no effect on insulin concentration during the treatment period (P > 0.20) while FCORT tended to be higher (19 vs. 16 ng/g fecal DM, P ≤ 0.14) during overstocking. During the GTT, cows took longer to return to basal glucose concentration (55.1 vs. 51.5 min, P = 0.05), tended to have greater area under the curve estimates for glucose (2837 vs. 2630 mg/dl × 120 min, P = 0.06), had lower peak insulin concentrations (201 vs. 260 μIU/L, P = 0.02), and tended to have a reduced rate of NEFA decline from circulation (1.4 vs. 1.9 μEq/L per min, P = 0.1) following the overstocked treatment. Cortisol production after administration of ACTH was not affected by stocking density treatment (P > 0.48). Overstocking alters energy metabolism. These effects seem to be mediated through changes in insulin production rather than insulin resistance; the role of glucocorticoids in influencing these effects is still unclear.

Key words: overstocking, energy metabolism, cortisol

Insulin-glucose clamps and intramammary LPS challenge: cross reactions between metabolism and mammary immune response. M. C. M. B. Vernay, L. Kreipe, H. A. van Dorland, R. M. Bruckmaier, and O. Wellnitz*, Veterinary Physiology, Vetsuisse Faculty, University of Bern, Bern, Switzerland.

Insulin, a central regulator of carbohydrate and fat metabolism, influences the immune system. The aim of this study was to evaluate the effects of a 3-d hypoglycemia and hyperinsulinemia/euglycemia on the bovine mammary immune system. Seventeen milking cows, non pregnant, anestric dairy cows received an insulin infusion (HypoG; n=5; constant plasma hypoglycemia of 2.32 ± 0.33mmol/L), an euglycemic hyperinsulinemic clamp (EuG; n=6; insulin infusion rate: 0.62mU/kg/min), or saline solution (control; n=6) for 56 h. 48 h after the start of infusion two udder quarters were challenged with lipopolysaccharide (LPS). Only significant results (P ≤ 0.05) are shown. Intramammary LPS challenge induced an insulin resistance indicated by an increase of plasma insulin (between 32 and 252μIU/L) in all groups, while glucose remained stable in controls, glucose infusion rates in EuG had to be markedly reduced (from 2.9 to 0.9 mmol/kg/min), and insulin infusion rates in HypoG had to be increased (from 0.2 to 0.9 mU/kg/min) to maintain constant glucose levels. AUC of plasma insulin was 333 in control, 875 in EuG, and 529 in HypoG. Hourly measurements of SCC showed increases to >10⁶ cells/mL in LPS treated quarters without differences between groups. mRNA abundance of immune parameters in mammary tissue biopsies before and 8 h after LPS administration was quantified by qRT-PCR: LPS induced an increased expression (between 2.1 and 8.4 crossing points) of tumor necrosis factor-α, interleukin (IL)-8, −1β, and −10, and serum amyloid A (SAA). IL-1β, IL-10, and SAA were higher expressed (difference between 2.2 and 3.6 crossing points) in LPS treated quarters of EuG than of HypoG. In conclusion, intramammary LPS challenge induces insulin resistance characterized by increased insulin release independently of insulin and glucose plasma concentrations before challenge. Increased plasma insulin occurs concomitantly with changes of the mammary immune response to LPS based on mRNA expression of measured immune factors. The results indicate cross-reactions between insulin resistance and cytokine release in the bovine mammary gland.

Key words: insulin, mammary immunity, intramammary LPS challenge
Insulin sensitivity in tropically adapted cattle selected for residual feed intake. G. L. Shafer1,2, A. W. Lewis1, L. C. Caldwell1, A. N. Hafla2, G. E. Carstens2, T. D. A. Forbes3, T. H. Welsh Jr2, and R. D. Randel1, *1Texas AgriLife Research, Overton, 2Texas AgriLife Research, College Station, 3Texas AgriLife Research, Uvalde.

Residual feed intake (RFI) identifies animals requiring less feed to achieve the same performance. This study evaluated the effect of a glucose (G) challenge on efficient (L) and inefficient (H) tropically adapted yearling bulls and heifers. Bonsmara heifers (n = 24) and Santa Gertrudis bulls (n = 16) were tested at different times and data analyzed separately. Animals were infused with a 50% dextrose solution at 0.5 mL/kg BW by catheter. Blood was collected at −5, 0, (heifer: 5), 10, 15, 20, (bull: 30), 40, 60, 80, 100, 120, 140, 160, and 180 min relative to challenge. Insulin (I) was determined by RIA and G by colorimetry. Repeated measures ANOVA were conducted using the MIXED model of SAS for analysis of RFI, time, and their interactions on I, G and insulinogenic index (IND). Time to peak I and half-life of G were analyzed using GLM. In bulls, time affected (P < 0.001) I and G. RFI did not affect (P > 0.05) I peak or peak time in bulls. L and H bull I peaks were (mIU/mL) 50.6 ± 13.3 and 67.7 ± 13.3, respectively and I peak times (min) were 46.2 ± 23.1 and 81.2 ± 23.1, respectively. RFI did not affect (P > 0.05) G half life in bulls. IND was affected by RFI (P < 0.05), but not time. L and H bull IND (ΔI/ΔG) were 0.17 ± 0.02 and 0.26 ± 0.02, respectively. Among heifers time affected (P < 0.0001) I and G. There was no RFI x time interaction (P > 0.05) for I or G. RFI did not affect (P > 0.05) I peak or peak time. L and H heifers had I peaks (mIU/mL) of 108.0 ± 12.0 and 75.5 ± 12.6, respectively and I peak times (min) were 16.6 ± 1.0 and 18.6 ± 1.0, respectively. RFI did not affect (P > 0.05) G half life in heifers. L and H heifer G half lives were (mg/dL) 80.0 ± 3.1 and 77.0 ± 3.2, respectively and G half life times (min) were 33.2 ± 2.5 and 36.9 ± 2.6, respectively. IND was affected by RFI (P < 0.05), but not time. L and H heifer IND (ΔI/ΔG) were 0.44 ± 0.02 and 0.29 ± 0.03, respectively. L heifers had a higher I response than H heifers. The opposite response was seen in bulls. There may be differences in energy metabolism between genders and breeds. Further research will be required to explain the opposite results of Bonsmara heifers and Santa Gertrudis bulls.

Key words: insulin, glucose, residual feed intake