

**353 Developmental and nutritional regulation of steroid receptor mRNA expression and epithelial cell proliferation in the prepubertal bovine mammary gland.** M. J. Meyer<sup>\*1</sup>, A. V. Capuco<sup>2</sup>, A. Hummel<sup>2</sup>, E. E. Connor<sup>2</sup>, Y. R. Boisclair<sup>1</sup>, and M. E. Van Amburgh<sup>1</sup>, <sup>1</sup>Cornell University, Ithaca, NY, <sup>2</sup>USDA-ARS, Beltsville, MD.

Estrogen and its alpha receptor (ER $\alpha$ ) are thought to mediate the ovaries influence on prepubertal mammary epithelial cell proliferation (MEP) in the bovine. The ER beta isoform (ER $\beta$ ) and the estrogen-related receptor  $\alpha$ 1 (ERR $\alpha$ 1) may also play a role in estrogen mediated MEP. To better understand these relationships, the developmental and nutritional regulation of ER $\alpha$ , ER $\beta$ , and ERR $\alpha$ 1 mRNA abundance was determined in prepubertal bovine mammary parenchyma (PAR) and fat pad (FP) by real-time RT-PCR. Holstein heifers (n = 72) were fed to grow at 950 (E) and 650 (R) g/d from birth to slaughter at 50kg increments between 100 to 350kg BW. MEP was assessed by BrdU labeling and estrogen responsiveness by quantity of progesterone receptor (PR) transcript. ER $\beta$  mRNA abundance was exceedingly low and appeared unregulated. E-heifers tended to have greater abundance of ER $\alpha$ , ERR $\alpha$ 1, and PR mRNA in PAR (P < 0.10) and greater ER $\alpha$  mRNA abundance in FP (P < 0.05) than R-heifers. Furthermore, expression of ER $\alpha$  was localized to FP fibroblasts by immunohistochemistry. ER $\alpha$ , ERR $\alpha$ 1, and PR mRNA abundance decreased linearly (P < 0.08) with increasing BW in PAR but not in FP. At 100kg, E- had greater MEP than R-heifers (P < 0.05). Beyond 100kg, MEP decreased rapidly with increasing BW and was similar between treatments. Among all heifers, MEP and PAR PR mRNA were positively correlated with PAR ER $\alpha$  mRNA abundance (r = 0.42 and 0.80, respectively, P < 0.05). Data suggest that expression of ER $\alpha$ , ERR $\alpha$ 1 and PR are developmentally regulated within PAR but not FP, implying tissue specific regulation of

these genes. Energy intake appears to increase PAR expression of these transcripts, but has no effect on MEP.

**Key Words:** Heifer, Mammary Development, Estrogen Receptor

**354 Estrogen and progesterone response networks in the mouse mammary gland.** D. J. Jerry<sup>\*</sup>, S. Lu, A. L. Roberts, and K. A. Dunphy, *Department of Veterinary & Animal Sciences, University of Massachusetts, Amherst.*

A majority of mammary gland development occurs post-natally and is controlled by many environmental factors including nutrition, exposure to environmental compounds and endogenous hormone status. The complement of signals not only influence milk yield in subsequent lactations in livestock, but have a striking effect on subsequent risk of breast cancer in humans. The p53 tumor suppressor protein senses cellular stresses and arbitrates the decision of whether a cell should undergo arrest, senescence or apoptosis. Given the gravity of these decisions, it would be expected that levels of p53 activity should be constrained within physiological limits so that cells are not removed inappropriately resulting in loss of secretory epithelium. Nor should levels of p53 be impaired excessively as cells bearing genetic alterations would be allowed to survive raising the risk of cancer. The physiologic role of p53 in the mammary gland is most evident in the fact that impaired p53 function results in delayed involution in rodents. Similarly, activity of p53 is enhanced by estrogen and progesterone, presumably to enforce heightened surveillance of cells undergoing replication to ensure that genomic integrity is maintained. Therefore, we undertook a series of experiments to map the transcriptional responses initiated by these hormones that are crucial to both growth and development of the mammary epithelium as well as suppression of mammary tumorigenesis.

**Key Words:** Mammary, Estrogen, Progesterone

## Ruminant Nutrition: Science of Ruminant Nitrogen Metabolism and Its Application to Feeding Cows

**355 What is the true supply of amino acids?** H. Lapierre<sup>\*1</sup>, D. Pacheco<sup>1</sup>, R. Berthiaume<sup>1</sup>, D. R. Ouellet<sup>1</sup>, C. G. Schwab<sup>2</sup>, G. Holtrop<sup>3</sup>, and G. E. Lobley<sup>3</sup>, <sup>1</sup>Lennoxville Research Centre, AAFC, Lennoxville, QC, Canada, <sup>2</sup>University of New Hampshire, Durham, <sup>3</sup>BIOSS, Rowett Research Institute, Aberdeen, UK.

Improving the prediction of milk protein yield relies on knowledge of both protein supply and requirement. Definition of protein/amino acid (AA) supply in ruminants is a challenging task, due to feedstuff variety and variability, and to the remodeling of nutrient intake by the rumen microflora. So, how and where should we measure the real supply of AA in the dairy cow? This review will follow the downstream flow of AA from duodenum to peripheral tissue delivery, with a glance at the efficiency of transfer into milk protein. Duodenal AA flow comprises rumen undegradable feed, microbial protein, and endogenous secretions. Most attention has been directed towards definition of the first two contributions, but the latter fraction can represent up to 20% of flow and more information is needed on what factors affect its magnitude and overall impact. Once digested, AA are absorbed into the portal vein. The ratio of portal absorption to small intestinal apparent digestion varies among AA, from 0.50 (threonine) to 0.85 (histidine), due to pre-duodenal endogenous secretions, non-reabsorption of intestinal endogenous secretions and gut oxidation of AA. Few data are available on these phenomena in dairy cows, but the evidence indicates that they alter the profile of AA available for anabolic purposes. Recent comparisons of estimated duodenal flux and measured portal flux have prompted a revisit of the NRC (2001) approach to estimate AA flows at the duodenum. New equations are proposed that yield predictions that better fit the current knowledge of AA metabolism across the gut. Absorbed AA flow first to the liver, where substantial and differential net removal occurs, varying from zero for the branched-chain AA to 0.50 of portal absorption for phenylalanine. This process alters the pattern of net supply to the mammary gland. Overall, intermediary metabolism of AA between the duodenum and the mammary gland biologically explains the decreased efficiency of the transfer of absorbed AA into milk protein as maximal yield is approached. Therefore, variable, rather than fixed factors for transfer efficiencies, must be incorporated into future predictive models.

**Key Words:** Dairy Cows, Amino Acids, Splanchnic

**356 Impacts of the source and amount of crude protein on the intestinal supply of nitrogen fractions and performance of lactating dairy cows.** J. H. Clark<sup>\*</sup> and I. R. Ipharraguerre, *Department of Animal Sciences, University of Illinois, Urbana.*

At the onset of a new century, increasing cow productivity and concerns about the environment and safety of food for human and animal consumption in combination with shrinking profits of dairy producers have renewed the challenge first faced by scientists almost 100 years ago. That is, it is fundamental to establish the minimum amount of protein required by today's high-producing dairy cows for achieving optimal milk production. In addition, it is important to identify protein sources that will accomplish that goal with maximum efficiency from a nutritional and economical standpoint. The main objective of this paper is to review and summarize the impacts of the source and amount of dietary crude protein on the supply of nitrogen fractions to the small intestine and the consequential performance of lactating dairy cows. An attempt will be made to quantitatively integrate literature data into a summary that will contribute to our understanding of the flow of protein fractions from the rumen of dairy cows and their effects on dietary protein requirements. Specifically, this approach will focus on providing estimates of the magnitude and significance of documented alterations in the supply of nitrogen fractions to the lower gastrointestinal tract and performance of dairy cows in response to manipulations of the amount and source of dietary crude protein. The ultimate goal of this review is to provide information that may be helpful for identifying areas where further research is required, for comparing new research outcomes, or for evaluating parameterization of computer-based models currently used for predicting the response of lactating cows to the feeding of different diets.

**Key Words:** Crude Protein, Dairy Cows, Review

**357 Nitrogen Supply to the Lower Gut and Its Relationship to Animal Performance in Beef Cattle.** T. J. Klopfenstein<sup>\*</sup> and G. E. Erickson, *University of Nebraska, Lincoln.*

Beef cattle require amino acids for maintenance and growth. The amino acids are supplied to the lower gut as microbial protein and undegraded

intake protein (UIP). The balance of amino acids depends upon the proportion of UIP and the amino acid spectrum of the UIP. Therefore, it is absolutely essential to measure or predict the relative amounts of MP (metabolizable protein) from microbes and UIP in any given feeding scenario. Both the production potential of the beef animal and microbial protein synthesis are driven by energy. It is impossible to predict MP supplied to the lower gut and MP needs of the animal without having accurate estimates of energy needs, energy supplies and ruminal energy availability. While there are many variations on beef production systems, most are based on high grain (finishing) diets or high forage diets. Forage contains little UIP and that UIP appears to be poorly digested (<50%). Without supplements, essentially all of the MP in forage feeding situations is supplied by microbes. Site of carbohydrate digestion (NDF) is relatively predictable and methodology for measuring forage protein degradation is relatively precise (NDF-N). Degradable intake protein (DIP) may be deficient in some situations. Microbial protein synthesis efficiency decreases as diet TDN decreases from 60% down to 45 to 50%. Low microbial production and low forage UIP create MP deficiencies in many forage feeding situations. On high grain diets, energy supply is high but microbial efficiency is limited by low ruminal pH. Site of carbohydrate digestion (starch) varies with grain type and processing. Estimation of ruminal degradation of grain (starch and protein) is not precise. DIP is usually required. Byproducts reduce starch, raise pH and add protein (maybe DIP or UIP depending on byproduct). Corn is high in UIP and the UIP is highly digested (>90%). Therefore feedlot cattle generally have adequate supplies of MP. It is difficult to produce an amino acid deficiency in feedlot cattle. Growing cattle can be deficient in specific amino acids depending upon the amino acid balance in the UIP.

**Key Words:** Beef Cattle, Metabolizable Protein, Amino Acids

## Swine Species Symposium. Improving Sow Productivity: Recent Developments in Gilt and Lactation Management

**359 Increasing weaning age improves pig performance and profitability in a multi-site production system.** R. G. Main\*, S. S. Dritz, M. D. Tokach, R. D. Goodband, and J. L. Nelssen, *Kansas State University, Manhattan.*

Two trials were conducted to determine the effects of weaning age on growing pig biologic and economic performance in a multi-site production system. Trial 2 also evaluated the effects of modifying nursery feed budgets according to weaning age. In trial 1 (2,272 pigs), treatments included weaning litters at 12, 15, 18, or 21 d of age. In trial 2 (3,456 pigs), litters were weaned at 15, 16, 18, 19, 21, or 22 d of age and categorized into three treatments (15.5, 18.5, or 21.5 d of age). In trial 2, pigs in each age group were fed a nursery feed budget classified as more or less complex. Since feed budget did not affect ( $P > 0.27$ ) performance, only weaning age effects are presented. Each trial was conducted as a randomized complete block design with four blocks of linked nursery and finishing sites (6 and 10 reps/block in trials 1 and 2, respectively). All wean age treatments were weaned from a 7,300-head sow farm on the same day into the same nursery. Each block remained intact as pigs moved from nursery to finishing site. Costs and revenue were measured for each pen. Increasing weaning age (12, 15, 18, or 21; and 15.5, 18.5, or 21.5 in trials 1 and 2, respectively) improved (linear,  $P < 0.03$ ) wean-to-finish ADG (580, 616, 637,  $687 \pm 8$  g/d; 676, 697,  $722 \pm 6$  g/d), mortality rate (9.4, 7.9, 6.8,  $3.6 \pm 0.95$  %; 3.9, 3.4,  $2.5 \pm 0.5$  %), weight sold per pig weaned (94.1, 100.5, 104.4,  $113.1 \pm 1.3$  kg, 107.6, 111.6,  $116.2 \pm 1.1$  kg), income over costs (\$2.00, 5.11, 7.12,  $11.19 \pm 0.52$ /pig; \$7.99, 10.04,  $12.46 \pm 0.46$ /pig), and cost per hundred kg sold (\$86.19, 83.24, 81.49,  $78.36 \pm 0.46$ ; \$80.80, 79.25,  $77.50 \pm 0.32$ ). The improvements in growth and mortality largely occurred in the initial 42 d after weaning, with smaller growth improvements in finishing. These studies indicate that increasing weaning age up to 21.5 d predictably improves grow-finish throughput ( $1.80 \pm 0.12$  kg sold/pig/d of age) and profitability ( $\$0.89 \pm 0.05$ /pig/d of age) within this multi-site production system.

**Key Words:** Weaning Age, Pigs, Economics

**358 Mathematical models used to determine ruminant protein requirements and availabilities.** R. A. Kohn\*<sup>1</sup> and M. D. Hanigan<sup>2</sup>, <sup>1</sup>University of Maryland, College Park, <sup>2</sup>Land O' Lakes/Farmland Feeds, LLC, St. Louis, MO.

The objective of this presentation is to review the functional differences between mathematical models that are used to formulate diets for beef and dairy cattle with respect to protein and amino acid requirements. An ideal model for diet formulation would require minimal data input to accurately predict the amount and form of protein required by the animal and supplied by available feedstuffs. Where appropriate, there should be a means to incorporate feed analysis results into the model to improve predictions. All current models divide dietary crude protein into two parts: that required by ruminal microbes and that required at the small intestine as true feed protein that has not been digested by ruminal microbes. The most recent models have established specific requirements and availabilities of the first limiting amino acids (e.g. lys, met). The Cornell model (CNCPS) also formulates for required amino acid and peptide protein (as opposed to non-protein nitrogen) for rumen fermentation. The 2001 NRC can incorporate soluble protein information, and the CNCPS can use protein solubility in buffers and detergents as indicators of protein degradation. When several models (NRC, 1989; CNCPS, CPM Dairy) were compared for their ability to predict protein flows to the small intestine for typical diets and cows, there were no obvious advantages for any one model. However, the NRC, 1989 was best able to predict losses in milk production due to underfeeding of protein to dairy cows. The 2001 NRC increased both RDP and RUP requirements for dairy cows without affecting the supply. As a result, the total CP recommended in diets increased for the 2001 NRC compared to the 1989 version. However, the amount recommended in the 1989 NRC was adequate. The various models that currently are available differ substantially in their level of complexity and the number and type of feed analyses that can be used. But, there is little evidence that this increased complexity has improved the accuracy of model predictions for typical farm conditions.

**Key Words:** Protein Requirements, Mathematical Models

**360 Behavior of sows during lactation.** J. McGlone\*, *Pork Industry Institute, Texas Tech University, Lubbock.*

Sow behavior is influenced by their genes and by their environment. During lactation, sows undergo significant changes in physiology that cause large behavioral changes. The objective of this review is to summarize the literature on sow behavior during lactation and the effects of management practices (such as weaning age and housing system) on sow behavior. Also, this review will summarize sow behaviors that lead to problems with the lactating sow or piglets. Sows undergo four major phases of behavior in the peri-lactation phase. First, prior to farrowing, sows undergo nest-building behavior that may involve building of an actual nest if sows are given building materials or expression of phantom nest-building behaviors in the absence of building materials. The second phase involves the establishment of the maternal-neonatal bond. This phase requires 12 to 24 h and is critical for piglet survival and growth. Maternal pheromones are secreted and the piglet is able to suckle in the presence of maternal pheromones. The piglet also is able to recognize its mother by her odor signature. The third phase is the lactation phase in which sows and piglets organize suckling with an interval of 40 to 50 min between nursing bouts. As piglets become larger, they will have larger, but less frequent meals - this trend continues from birth through market age. If given the opportunity, sows will spend less time with piglets as lactation progresses. The fourth phase is the weaning phase which can be gradual or abrupt and includes weaning and the weaning to estrus interval. Natural weaning by the sow can take place at any time from 3 d to 6 months of age. Sow genotype and the housing system can have major impacts on pig behavior during each phase. Weaning age will significantly impact phase 3 and 4 sow behaviors. Sow welfare including stress-related behaviors, wounds, scratches, injuries, weight loss and body condition are influenced by the behavior sows express as a result of their genotype, housing system and management practices.

**Key Words:** Pigs, Lactation, Behavior