

**ABSTRACTS**  
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\* Author Presenting Paper

**Animal Behavior, Housing, And Well-Being**

**1 The effects of exogenous ACTH on the growth performance, fat distribution and organ weights of growing pigs.** R. Morrison<sup>\*1</sup>, P. Hemsworth<sup>2</sup>, G. Cronin<sup>2</sup>, and R. Campbell<sup>3</sup>, <sup>1</sup>University of Minnesota, MN, <sup>2</sup>Victorian Institute of Animal Science, Werribee, Australia, <sup>3</sup>United Feeds, Sheridan, IN.

Our objective was to study the influence of the stress response (chronic stress) on pig growth performance, fat distribution and organ weights. Neuroendocrine responses such as elevated concentrations of catecholamines, adrenocorticotrophic hormone (ACTH) and corticosteroids are known to have effects on pig growth performance. In order to study the effects of chronic stress on growth performance, 30 intact male growing pigs (Large White x Landrace - initial BW= 77.4 kg) were individually housed indoors in pens measuring 2.4 x 0.9 m from 19 to 22 weeks of age. Commercial male finisher diet (13.7 MJDE, 14.7% crude protein and 0.5g/MJDE available lysine) in a pelleted form was fed to the pigs ad libitum in single-spaced, dry-feed feeders. Two treatments commencing at 20 weeks of age were studied: ACTH-daily intramuscular injections of 100 IU ACTH/ml/pig and Control-daily intramuscular injections of 1 ml of saline. The treatments were administered for 21 consecutive days. Blood sampling was conducted on five pigs per treatment on days 18 and 19 of treatment, at 1300, 1400 and 1500 hours. The ACTH treatment was successful in causing sustained elevated plasma cortisol concentrations (303.5 vs 29.7nM;  $P<0.001$ ). Pigs in the ACTH treatment were significantly heavier (111.5 vs 106.4 kg;  $P<0.05$ ) at 23 weeks of age and they had a higher rate of gain (1.3 vs 1.1 kg/day;  $P<0.05$ ) and daily feed intake (3.8 vs 3.0 kg/day;  $P<0.001$ ) than the Control treatment. The pigs in the ACTH treatment also had significantly higher carcass fatness (16.7 vs 13.4 mm;  $P<0.001$ ), heavier total viscera (10.6 vs 9.7 kg;  $P<0.01$ ) and digestive system (8.2 vs 7.3 kg;  $P<0.01$ ) and more visceral fat (1.0 vs 0.65 kg;  $P<0.01$ ). These data suggest that stress physiology significantly affects pig growth performance, fat distribution and organ weights. More research needs to be conducted on effects of the stress response, particularly the magnitude of the stress response on pig growth performance.

**Key Words:** Pigs, Welfare, Stress Physiology

**2 Using daily spraying of oil to control dust and odor in swine grow-finish confinement building.** T. E. Socha<sup>\*</sup> and B. S. Zimprich, North Dakota State University.

One hundred ninety-two pigs were allocated to 24 pens of eight pigs each. The room was divided into two parts with 12 pens in each half. Plastic was used to divide the room and both halves had the same fans to ensure the same amount of ventilation in each section. An oil mixture containing 10% vegetable oil and 90% water was sprayed each day for two minutes. Bi-weekly measurements were taken for ammonia levels and dust collections. Dust was collected using a filter on a vacuum and a filter on one of the exhaust fans. The pigs were weighed on test and off test to calculate daily gain. Feed was weighed into each feeder and feed efficiency was calculated. Lungs were evaluated at slaughter for the presence of lesions. The pigs were started on test at 37kg and removed at 113kg. The experiment was conducted for 12 weeks. The oil treated section had higher ammonia levels than the untreated section (8.41 vs 6.96 ppm;  $p < 0.05$ ). There were no differences in the amount of dust collected by the vacuum or the exhaust fan between the treated and untreated sections. Feed efficiency did not differ but the oil treated section had lower ADG than the untreated section (790 vs 813 gm;  $p = 0.05$ ). The pigs were examined for the presence of lung lesions. There was no difference in percent of lungs with lesions (36 vs 32 %) between the two groups. Daily spraying with an oil mixture did not improvement the environment, pig performance or presence of lung lesions.

**Key Words:** Swine, Grow-finish, Dust Control

**3 Boar Teasing Methods: Time to Mount and Semen Characteristics.** K.A. Fischer<sup>\*1</sup>, T.J. Safranski<sup>1</sup>, and S.L. Terlouw<sup>2</sup>, <sup>1</sup>University of Missouri, Columbia, MO, USA, <sup>2</sup>Premium Standard Farms, Princeton, MO, USA.

Utilization of artificial insemination in swine has led to increased emphasis on boar productivity. Teasing methods, such as false mounting, are used to increase semen output of bulls but have not been examined in boars. This study evaluated effects of false mounting (FM) and allowing a boar to observe collection prior to its own collection, hot pen (HP), on time to mount the dummy (TTM) and ejaculate characteristics. Dalland L80 boars in a commercial stud in Texas were randomly

assigned to FM or HP in a 2x2 factorial arrangement. Data were collected on 181 ejaculates from 92 boars. FM boars would mount the dummy, thrust, be pushed off two consecutive times, and collected on their third mount. HP boars observed collection of another boar immediately prior to their own collection. Data were collected between June 25 and July 30, 2001 with a minimum 4d rest between collections. A model including HP, FM, HPxFM, collector, boar age, and date of collection was used to test effects on the dependent variables TTM, semen volume, concentration, total cell count, motility, and total motile cell count. TTM was recorded from the time the boar entered the collection pen until complete erection of the penis. TTM was decreased by HP (3.95 minutes versus 5.59 minutes,  $P < 0.001$ ), but FM led to 1.12 additional minutes ( $P < 0.05$ ) until the final mount. There was no interaction between HP and FM for TTM. Among the three technicians the total sperm cell count per ejaculate ranged from 77.26 to 92.38 billion cells ( $P < 0.05$ ). No differences were found in semen volume (mean=279.90 ml), concentration (mean=313x10<sup>6</sup> cells/ml), total number of cells (mean=83.3x10<sup>9</sup> cells), motility (mean=86.51%), or total number of motile cells (mean=72.6x10<sup>9</sup> cells). Failure to mount the dummy within 15 minutes occurred six times. These were either FM or the combination FM and HP. Allowing boars access to HP reduces TTM with no effects on ejaculate characteristics. FM increases TTM with no effect on ejaculates, but may result in some boars that cannot be collected.

**Key Words:** Boar, Tease, Ejaculate

#### 4 Accounting for wind speed and solar radiation in the temperature-humidity index. M.S. Davis\* and T.L. Mader, University of Nebraska.

Wind speed (WSPD) and solar radiation (RAD) are known factors contributing to the degree of heat stress to which feedlot cattle are subjected. However, the most commonly used indicator of heat stress for feedlot cattle (Livestock Weather Safety Index) uses only the temperature-humidity index (THI) and does not account for WSPD or RAD. Accurate adjustment to the THI equation based on WSPD and RAD are essential in determining level of heat stress. Therefore, visual assessments of heat stress based on panting scores (PS; 0 = no panting, 4 = severe panting) were collected at 1700 during three previously conducted summer studies. These data were combined into one data set and included 5520 observations. Treatments imposed during these studies were designed to reduce heat stress in feedlot cattle; however, their effect on panting score was minimal. A weather station, located in the facility where cattle were confined, recorded THI and WSPD (m/s). Solar radiation (W/m<sup>2</sup>) was recorded .7 km West and 1.7 km North of the facility. Temperature-humidity index averaged  $79.7 \pm 5.2$  (range 63.9 to 86.2) at the time PS were assigned. A regression equation (RE) was developed using THI, WSPD, and RAD to predict PS ( $PS = -6.317 + (0.097 \times THI) + (0.233 \times WSPD) + (0.0026 \times RAD)$ ). Using this equation, mean THI was entered into the equation and held constant, while WSPD and RAD were adjusted using mean values  $\pm 1$  std. err. The RE equation was then solved for THI using each calculated PS and mean values for WSPD and RAD. The calculated THI was then regressed against its corresponding WSPD and RAD value. The slopes of these lines (-2.400 and 0.027 for WSPD and RAD, respectively) represent the adjustments to the THI for WSPD and RAD. For instance, for each 1 m/s (2.24 mph) increase in WSPD, THI is reduced 2.4 units, and for each 100 W/m<sup>2</sup> decrease in RAD (25% increase in cloud cover) THI is reduced 2.7 units. Although, knowledge of THI alone is beneficial in determining the potential for heat stress, accurate adjustments for WSPD and RAD are essential to more accurately represent the degree of animal comfort.

**Key Words:** Temperature-humidity Index, Wind Speed, Solar Radiation

#### 5 Behavioral responses of foals subjected to short term maternal separations. J. Bohm\*, M. Leavitt, and A. Zanella, Michigan State University, East Lansing.

Foals may experience stress and poor welfare as a result of disease or inadequate husbandry procedures. A precise assessment of behavioral changes post-maternal separation has yet to be examined. Changes in body postures following a challenging situation may indicate the severity of the procedure. We measured behavioral responses in five foals,

three fillies and two colts, separated from their mothers for 10 min. We carried out behavioral observations for 2 hours before and 2 hours after bi-weekly separations between the ages of 15 and 75 days. Mares and foals were video recorded and tapes were analyzed using a scan sampling technique at 10 min intervals. Twelve scans were collected before and after separations. A transition was defined as a movement or change in position of the body from one plane to another. Proximity was measured in millimeters from a midpoint on the mare's head to a midpoint on the foal's head. Data from two independent observers were compared for total transitions (TT) and estimated distance between mare and foal (EDBMF) using Pearson's correlation coefficient. Both datasets yielded identical results for TT and EDBMF ( $R^2 > 0.97$ ). The impact of maternal separation and age on TT and EDBMF was analyzed using ANOVA. Results are presented as mean  $\pm$  SEM. Foals showed a higher frequency of TT during the 2 hours post-maternal separation than in the 2 hours pre-separation ( $10.68 \pm 0.236$  and  $9.6 \pm 0.351$ ;  $P = 0.01$ ). EDBMF was not affected by maternal separations ( $P > 0.3$ ). Age tended to affect TT post-maternal separation ( $P < 0.1$ ). Further analysis revealed that foals showed higher frequencies of TT during the sixth separations than during the 3rd & 4th separations ( $P < 0.05$ ). Overall, age did not affect EDBMF ( $P = 0.34$ ). We demonstrated that behavioral transitions post-maternal separation may be related the severity of the challenge. EDBMF yielded less convincing information than TT. The significance of these findings needs to be evaluated with caution given the limited number of animals observed and the artificial threshold imposed in the EDBMF measures by the stall design.

**Key Words:** Foals, Maternal Separation, Behavior

#### 6 Immunomodulation by oral supplementation of ascorbic acid and beta-glucan to transported dairy calves. S.D. Eicher\*<sup>1</sup> and T.R. Johnson<sup>2</sup>, <sup>1</sup>USDA-ARS, West Lafayette, IN., <sup>2</sup>Purdue University, West Lafayette, IN.

In previous work, a yeast cell-wall derivative (Energy-plus, Natural Chem Industries, LTD) worked synergistically with ascorbic acid (Stay-C, Roche Vitamins) to enhance growth in neonatal calves housed indoors in raised calf crates. Objectives of this study were: 1) to ascertain if these supplements would improve neonatal calves' innate immunity and ability to cope with transportation and 2) to compare the yeast cell-wall derivative with purified  $\beta$ -glucan from yeast cell-walls. Thirty-nine bull and heifer calves were blocked by sex and age, then assigned to treatments: 1) IG; 113 g Energy-plus and 250 mg Stay-C, 2) BG; 150 mg of a  $\beta$ -glucan fraction from yeast cell-walls equivalent to that contained in Energy-plus (Biopolymer Engineering) plus Stay-C, or 3) Cnt; a positive control given subcutaneous electrolytes, but no supplements. Calves were fed milk replacer at 4.45 kg/d with supplements in the milk replacer. Groups of calves (3 to 10 d of age) were transported for 4 h. After transport, treatments were started with calves housed in outdoor hutches. Jugular blood was collected pre- and post-transport, and d 3, 7, 10, 14, 21, and 28 post-transport for hematocrit determination, leukocyte counts, and neutrophil assays. Hematocrit percentages were least for BG compared to IG post-transport and d 21 ( $P < 0.05$ ) and compared to IG ( $P < 0.05$ ) on d 10 and both IG and Cnt on d 28 post-transport ( $P < 0.05$ ). Leukocyte numbers were least for BG compared to IG on d 21 ( $P = 0.06$ ) and d 28 ( $P < 0.05$ ). On d 21 post-transport, granulocyte numbers tended to be greater ( $P = 0.08$ ) for IG calves than for BG calves. Percentage of neutrophils positive for high CD18 expression was greater in the IG calves than for those of the BG or Cnt calves on d 28. Neutrophil phagocytosis was reduced in BG calves compared to Cnt calves ( $P < 0.05$ ) and tended to be reduced compared to IG calves ( $P < 0.10$ ) on d 28 and chemiluminescence was least in BG calves compared to the Cnt calves on d 28. These data showed that modulation by the supplements on innate immunity are not evident until 28 d post-transport. These data show that not all  $\beta$ -glucan containing products have the same effects on innate immunity.

**Key Words:** Dairy Transport, Innate Immunity, Neonatal Calf

**7 Florfenicol concentration in serum and lung lavage fluid of beef cattle fed various concentrations of dietary fat in a 70% concentrate diet.** G. C. Duff<sup>\*1</sup>, B. D. Hunsaker, A. C. Anderson<sup>2</sup>, J. D. Roder<sup>2</sup>, and D. A. Walker<sup>3</sup>, <sup>1</sup>The University of Arizona, Tucson, <sup>2</sup>Texas Tech Health Science Center, Amarillo, <sup>3</sup>Clayton Livestock Research Center, New Mexico State University.

Eighteen beef steers (British x Continental; average initial BW 329 kg) were used to evaluate effects of dietary fat (yellow grease) concentration on serum and lung lavage sample concentrations of florfenicol. Steers were assigned randomly to dietary fat concentrations and were housed in individual pens. Treatments were a 70% concentrate diet with 0% added fat (6 steers), 3% added fat (6 steers), and 6% added fat (6 steers). Steers were fed at approximately 2.25% (as-fed basis) of initial BW for 3 wk before sampling. Florfenicol (Nuflor; Schering-Plough Anim. Health) was administered s.c. at 40 mg/kg of BW in the neck. Serum and lung lavage samples were collected at 0, 6, 12, 24, 48, and 72 h after administration of florfenicol. Concentrations of florfenicol in lung lavage fluid and cells were non-detectable. In serum, no florfenicol concentrations were observed at 0 h. At 6 h, a quadratic response ( $P < 0.05$ ) was observed with highest concentrations of florfenicol observed with the 3% added fat. No differences ( $P > 0.10$ ) were observed at 12 h. At 24 h, however, a linear increase ( $P < 0.05$ ) in florfenicol concentration was noted with added dietary fat. No differences ( $P > 0.10$ ) were observed at 48 or 72 h. Results suggest that added dietary fat influences serum concentrations of florfenicol. However, methods more sensitive to small antibiotic concentrations need to be conducted to evaluate the effects of dietary fat on host tissue concentrations.

**Key Words:** Beef Cattle, Antibiotic, Dietary Fat

**8 Dynamic model for behavior of outdoor gestating sows with seasonal ambient temperatures.** H. A. Rachunyo, S. W. Kim<sup>\*</sup>, and J. J. McGlone, Texas Tech University, Lubbock.

The influence of ambient temperature on behavior of outdoor pregnant sows were evaluated and modeled using 91 sows during 24 h observation in winter, spring, and summer seasons. Minimum and maximum temperatures ranged from -10.7 to 39.2°C for data collection. Each of the 0.4-ha pastures were divided into hub, middle, wallow, outside, and feeding areas to determine variations in use of regions within the pasture. A hut and wallow-pool were located in the middle section of each pasture. Sows had free access across all pasture regions. Behavioral parameters of interest included standing, lying, rooting, drinking, and feeding. Trained observers recorded the number of sows in each region and behavioral activity using a 10-min scan technique for 24-h periods. Data were analyzed using logistic regression procedures and the equations derived were utilized to construct dynamic models using Powersim<sup>®</sup> for: (1) active behavior (standing, rooting, feeding, and drinking); (2) wallowing behavior (standing, lying, drinking, and rooting around the wallow area); (3) rooting behavior; and (4) use of hut. During temperatures of 15°C and below sows engaged in active and rooting behaviors during mid-day whereas during higher temperatures active behaviors were higher during morning and evening h. During cool temperatures sows spent morning and late afternoon hours in the hut, while during high temperatures sows were more often in the hut or wallow during the middle of the day. Sows used the hut for approximately 59% during day and almost 100% during night. Outside region was used for 10% during daytime, especially for rooting, while the hub and the wallow regions were used less. Rooting activity was in the outside region during cool temperatures. These models are useful in identifying behavioral changes over a wide range of seasonal temperatures; in describing sow motivational changes over seasons, and helping adjust sow management, especially during adverse weather.

**Key Words:** Sow, Behavior, Dynamic Model

**9 Effect of dietary cation-anion difference (DCAD) on stress responses in finisher swine exposed to a stress model system.** D. J. Ivers<sup>\*</sup>, R. K. McGuffey, T. A. Armstrong, D. J. Jones, D. H. Mowrey, L. F. Richardson, R. Seneriz, J. R. Wagner, K. L. Watkins, and D. B. Anderson, Elanco Animal Health, Greenfield, Indiana.

A study was conducted to investigate the effect of dietary cation-anion difference (DCAD =  $\text{meq} (\text{Na}^+ + \text{K}^+ - \text{Cl}^-)$ ) on the stress responses and downer incidence in finisher barrows fed 20 ppm ractopamine-HCl and exposed to aggressive handling in a model system (Benjamin, et al, 2001). Four days prior to the scheduled handling, the pigs were assigned to either a high DCAD diet (HD, +481 meq/kg) or a low DCAD diet (LD, +81 meq/kg). Ninety-six barrows (high-lean genetic line) were used in this study and were handled in 16 groups of 6 pigs. Each group of pigs consisted of 3 LD and 3 HD pigs. The stress model course consisted of walking the pigs 4 laps (~300 m and ~6.5 min) in a room set up with a 36.6 m long aisle (2.1 m wide narrowing to .6 m for ~20 m). An electric prod and sorting panel were used to move the pigs through the course. Blood samples were collected and rectal temperatures were measured prior to handling, immediately post-handling, and 2 hr post-handling. The pigs were observed for cyanosis, dyspnea, muscle tremors, and abnormal vocalizations. Pigs that became non-ambulatory during the course or exhibited multiple signs of distress after handling were classified as downer pigs. Fewer ( $P < 0.05$ ) downer pigs were observed on HD (18.8%) than LD (37.5%). Prior to and immediately after handling, blood pH,  $\text{HCO}_3^-$ , and base excess were higher ( $P < 0.05$ ) for HD than LD, but blood lactate was not different ( $P > 0.05$ ). Downer pigs had higher blood lactate and  $\text{NH}_4^+$ , and lower pH,  $\text{HCO}_3^-$ , and base excess than non-downer pigs following handling. This study demonstrated that: 1) aggressively-handled pigs rapidly develop metabolic acidosis; 2) metabolic acidosis is more severe in downer pigs than non-downer pigs; and 3) increasing the DCAD level 4 days prior to handling improved the blood buffering capacity and resulted in fewer downer pigs after handling.

**Key Words:** Electrolyte, Stress, Swine

**10 Physiological comparison of downer and non-downer pigs following transportation and unloading at a packing plant.** D. J. Ivers, L. F. Richardson, D. J. Jones, L. E. Watkins, K. D. Miller, J. R. Wagner, R. Seneriz, A. G. Zimmermann, K. A. Bowers, and D. B. Anderson<sup>\*</sup>, Elanco Animal Health, Greenfield, Indiana.

A study was conducted to physiologically characterize and compare downer and non-downer pigs following transportation and unloading at a Midwestern packing plant. The study had 70 pigs representing several genetic strains, barrows and gilts, and pigs having been fed diets with or without Paylean<sup>®</sup> (ractopamine-HCl). Pigs from the same truck were selected in pairs with one being a non-downer or normal pig and the other being a downer pig (non-ambulatory with no signs of physical injury). The pigs were observed for signs of stress such as cyanosis, dyspnea, abnormal vocalizations, and muscle tremors. Blood samples were drawn and assayed for blood gas measures and various blood chemical parameters. Glycolytic potential assays were conducted on muscle and liver samples. Skin biopsies were used to identify the presence of the porcine stress gene (RYR1). A false discovery rate controlling procedure was used in the statistical analysis to account for testing of multiple assay variables. Signs of stress were more frequently observed in the downer pigs than the non-downer pigs ( $P < 0.05$ ). Downer pigs had higher blood lactate,  $\text{NH}_4^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , cortisol, epinephrine, and norepinephrine concentrations than non-downer pigs ( $P < 0.05$ ). Base excess, pH,  $\text{Ca}^{2+}$ ,  $\text{HCO}_3^-$ , partial pressure of  $\text{CO}_2$ , and insulin were lower in downer pigs than non-downer pigs ( $P < 0.05$ ). Only three downer pigs were classified as stress gene carriers. Gilts were leaner with less back-fat than barrows ( $P < 0.05$ ). Downer pigs had lower glycolytic potential in the *longissimus dorsi* and the high red fiber portion of the *semitendinosus* and lower liver concentration of the combination of glucose, glucose-6-phosphate, and glycogen than non-downers ( $P < 0.05$ ). This study suggests the downer pig is in a state of metabolic acidosis and that the observed differences between downer and non-downer pigs are similar regardless of Paylean use or gender.

**Key Words:** Swine, Stress

## Breeding And Genetics

**11 Development of EST sequence data and map locations for genes expressed in major female reproductive tissues.** C.K. Tuggle<sup>1</sup>, J.A. Green<sup>2</sup>, C. Fitzsimmons<sup>1</sup>, R. Woods<sup>2</sup>, R.S. Prather<sup>2</sup>, S. Malchenko<sup>3</sup>, M.B. Soares<sup>3</sup>, C.A. Roberts<sup>3</sup>, K. Pedretti<sup>3</sup>, T. Casavant<sup>3</sup>, D. Pomp<sup>4</sup>, A. R. Caetano<sup>4</sup>, J. B. Edeal<sup>4</sup>, S. Oberginger<sup>4</sup>, Y. D. Zhang<sup>1</sup>, M. F. Rothschild<sup>1</sup>, K. Garwood<sup>5</sup>, and W. Beavis<sup>5</sup>, <sup>1</sup>*Iowa State University, Ames*, <sup>2</sup>*University of Missouri, Columbia*, <sup>3</sup>*University of Iowa, Iowa City*, <sup>4</sup>*University of Nebraska, Lincoln*, and <sup>5</sup>*National Center for Genomic Resources, Santa Fe, NM.*

A consortium of five institutions is developing extensive expressed sequence and mapping data for cDNAs expressed in major female reproductive tissues. We have produced 20 libraries from different stages of estrus or gestation for whole embryo, anterior pituitary, hypothalamus, ovary, uterus, and term placenta. The anterior pituitary, placenta and uterine libraries have been normalized. A total of 15,002 sequences from random clones has been produced and submitted to Genbank. The average read length across this dataset is ~400 base pairs. As assessed by clustering analysis, these data represent 9,042 different genes. A BLAST analysis indicates that 4,405 of these clusters are unique relative to existing porcine Genbank genes and ESTs (BLAST score <50). To facilitate selection of genes for comparative mapping, we have developed software to predict the cytogenetic location of pig ESTs. We identified human loci with a BLAST score >200 to our EST dataset, and then predicted the pig location of high-scoring ESTs based on human cytogenetic and RH mapping data, along with human:pig chromosome painting information. Pig EST matches to human loci with consistent cytogenetic and RH mapping locations total 1,486. Within the human genome, there is an average distance of  $9.4 \pm 5.8$  cR between loci with a pig EST match. On average, there is  $20.9 \pm 3.8$  RH-mapped genes between each human locus matched to a pig EST. To date, 50 loci have been mapped using both the SCHP and the RH panel. A WWW site has been established for access to these sequences and the analysis data (<http://pigest.genome.iastate.edu>).

**Key Words:** Pig EST Sequencing, Gene Mapping, Comparative Genomics

**12 Construction of a High Density Comparative Map of Bovine Chromosome 5 to Search for Genes Controlling Birth Weight.** Z. Liu\* and E. Antoniou, *University of Missouri-Columbia*.

The beef industry suffers an estimated \$226 million loss per year caused by dystocia. Dystocia is mainly due to calves with high birth weights. At the same time low birth weight in humans is associated with an increased risk of diabetes later in life. It might be the same genes in human and cattle that control birth weight. Bovine chromosome 5 (BTA5) was previously identified as containing genes controlling some of the genetic variance for birth weight (quantitative trait loci or QTL). We want to find these genes by applying the comparative candidate gene approach. However, the current comparative map of BTA5 with the human genome is too sparse to use this approach. Thus, we have created a high-density comparative map of BTA5. We used a radiation hybrid (RH) 12,000 rads DNA panel with 180 cell lines, which is by far the highest resolution bovine panel available. We mapped all known microsatellites (24) in the region as well as 40 genes selected from the human genome sequence. Our RH map for this region spans 26.45 cR and corresponds to a region spanning 71 cm on BTA5 genetic linkage map. Thus, the current resolution for this region of BTA5 is approximately one marker per cm.

**Key Words:** Comparative Map

**13 Evaluation of insulin-like growth factor binding proteins (IGFBP) in Angus cattle divergently selected for serum insulin-like growth factor-I (IGF-I) concentration.** M. Pagan<sup>1</sup>, M.E. Davis<sup>2</sup>, K. Kizilkaya<sup>1</sup>, R.J. Tempelman<sup>1</sup>, and C.W. Ernst<sup>1</sup>, <sup>1</sup>*Michigan State University, East Lansing*, <sup>2</sup>*The Ohio State University, Columbus*.

Angus cattle divergently selected for serum IGF-I concentration were genotyped for a *Hind* III restriction fragment length polymorphism at the IGFBP-2 locus identified in our laboratory. Genotyping of high and low IGF-I line individuals (born in spring 1995, fall 1995, fall 1997, fall

1998 and spring 1999;  $n = 366$ ) indicated no difference in allelic frequencies between the high (0.32 A/0.68 B) and low (0.31 A/0.69 B) IGF-I lines or between bull (0.32 A/0.68 B) and heifer (0.33 A/0.67 B) calves. Analysis of variance (ASREML) using genotypes and phenotypic data (weight and gain data and serum IGF-I concentrations) indicated that animals of BB genotype had higher birth weights than AA and AB animals ( $P < 0.05$ ). Phenotypic analysis of circulating IGFBP was also performed by <sup>125</sup>I-IGF-I western ligand blotting using serum samples obtained at d 56 of the postweaning test period from IGF-I selection line calves born in fall 1999 ( $n = 81$ ). Four IGFBP species of 42-38, 34, 30 and 24 kDa were identified. The 34 kDa IGFBP species was determined to be IGFBP-2 by immunoblotting using a bovine specific anti-IGFBP-2 antibody. The effects of line, sex and the line x sex interaction were determined by analysis of variance of data obtained by densitometric analysis of autoradiographs. No significant line effects or line x sex interactions were observed. A significant effect of sex was found for IGFBP-2 such that levels of this protein were higher in heifer than in bull calves ( $P < 0.05$ ). Serum levels of all IGFBP were positively correlated with each other and negatively correlated with growth traits and serum IGF-I concentrations ( $P < 0.0001$ ). Results of this study indicate that an association may exist between economically important traits in beef cattle and alleles of the IGFBP-2 gene as well as between these traits and serum IGFBP concentrations. This work further supports IGFBP-2 as an important candidate gene for beef cattle growth.

**Key Words:** Beef Cattle, IGFBP, Immunoblotting

**14 Control of hypothalamic gene expression in mice selected for heat loss.** S.R. Wesolowski\*, M.F. Allan, M.K. Nielsen, and D. Pomp, *University of Nebraska, Lincoln*.

Understanding the genetic complexity of energy balance in livestock species is essential to improve production efficiency. In the mouse, many physiological genes controlling energy regulating pathways are known, while several predisposition genes (QTL) are being identified for energy balance traits. The genetic map locations for these two subsets of genes are not well correlated, creating a possible complex genetic paradigm whereby predisposition and physiological genes represent different loci. To test this theory, we plan to identify predisposition genes for expression levels of physiological genes regulating energy balance. Mouse lines divergently selected for heat loss using direct calorimetry were created as model populations to dissect the genetic complexity of energy balance. Inbred lines were generated from these populations. The inbred high (IH) heat loss mice have 50% greater heat loss, 35% less body fat, 20% greater feed intake, two-fold greater activity levels, and one degree higher core body temperature compared to the inbred low (IL) heat loss mice. Yet, both lines are similar in body weight. We evaluated differences in hypothalamic gene expression between the IH and IL lines using replicated cDNA microarrays, differential display PCR, and selected candidate genes. Northern blot analysis was used to confirm relative mRNA abundance for individual genes. Of primary interest, hypothalamic gene expression of oxytocin was higher in the IH line. Sensitive real-time PCR assays are being developed to facilitate high-throughput screening in a large F2 population originating from a cross between IH and IL, for which genome-wide markers have already been scored and hypothalami stored. Identification of QTL for regulation of relevant gene expression changes will facilitate direct correlation between predisposition and physiology, and contribute towards a greater understanding of the complex genetic architecture of polygenic traits.

**Key Words:** Energy Balance, Microarrays, Oxytocin

**15 Comparison of statistical methods to study microarray data.** S. Rodriguez-Zas\*, *University of Illinois at Urbana-Champaign*.

Reliable methods to study the abundant and complex gene expression data resulting from livestock functional genomic research need to be developed and tested. The objective of this study was to develop a model to characterize the expression of thousands of DNA sequences across several instances (e.g., treatments, time points). The adequacy of the proposed approach was evaluated using data from a model organism that has an advanced functional genomic status, hence reflecting the livestock genomic situation in the immediate future. Data from a

study with replicates on the level of expression of 17,871 genes from *Caenorhabditis elegans* along six developmental stages were examined. The logarithm of the Cy3 (common reference cDNA) and Cy5 (developmental phase cDNA) intensities were normalized for the effects of dye and background effects. The difference between the adjusted developmental and reference sample intensities was described with a mixed effects model that accounted for the replicate effect. Two complementary ways to study the differential expression across stages were considered. The developmental stage was fitted as a classification variable or as a covariate expressed as hours in the life cycle. The correlation between the proposed model-based adjusted and conventionally normalized (equal total Cy5 and Cy3 signal) intensities ranged between 84% and 94% suggesting that the conventional normalization fails to account for critical dye and background effects. Results from the stage-dependent model indicated that multiple known and putative (unknown function) collagen-related genes were over expressed in the intermediate developmental stages. Many known and putative sperm-specific protein genes were under expressed during the egg stage and were over expressed in the late stages. The adjustment and instance-modeling approaches proposed provided a statistically and biologically meaningful answer to the analysis and interpretation of functional genomic studies that can be readily applied to livestock species.

**Key Words:** Gene Expression, Functional Genomics, Mixed Effects Model

**16 Measurement error in detecting quantitative trait loci with genetic markers.** G. J. M. Rosa<sup>\*1</sup>, B. S. Yandell<sup>2</sup>, and D. Gianola<sup>2</sup>, <sup>1</sup>Michigan State University, East Lansing, <sup>2</sup>University of Wisconsin, Madison.

The advent of molecular marker information has created opportunities for a better understanding of quantitative inheritance and for developing new strategies for genetic improvement in agriculture. Information on genetic markers is often used for two purposes: genetic marker map construction and quantitative trait loci (QTL) analysis. The map construction procedures use information from marker genotypes to make inferences regarding linkage, order and distances of marker loci. The QTL analysis puts together information on phenotypes and on marker genotypes to infer the number of QTL and their positions and effects on phenotypic variation. Most statistical methods ignore that molecular (marker) data may be read with error. Often, however, there is ambiguity about genotypes, which may lead to erroneous inferences. Moreover, QTL models for continuous traits rely almost invariably on Gaussian assumptions, which are known to be non-robust to discrepant (outlier) observations. Here, measurement error models are discussed for map construction and QTL search. Robust alternative methods consider the possibility of error-in-variables for both marker genotypes and trait phenotypes. For marker data, additional parameters are introduced to model the probability of genotyping error and, therefore, to correct miscoded genotypes. For measurement error in the phenotypes, thick-tailed (symmetric and skewed) distributions are used to accommodate outliers. A Bayesian framework is adopted throughout and Markov chain Monte Carlo methods are used to carry out the posterior analysis. Simulated and real data examples are discussed to illustrate the methodologies.

**Key Words:** QTL Analysis, Measurement Error, Robust Inference

**17 Power of least squares interval mapping compared to single marker analyses to detect QTL with selective DNA pooling.** J. Wang<sup>\*</sup> and J. Dekkers, Iowa State University, Ames.

Selective DNA pooling is an efficient method to identify chromosomal regions that harbor quantitative trait loci (QTL) by comparing marker allele frequencies in pooled DNA from phenotypically extreme individuals. Currently, single marker methods are used for analysis. These methods can detect linkage of markers to a QTL but do not provide separate estimates of QTL position and effect, nor do they utilize information on multiple linked markers. We recently developed a least squares regression interval mapping (LSIM) method to overcome these limitations. The objective of this research was to compare the power of this method to that of single marker analyses. Methods were applied to simulated DNA pooling data from the top and bottom 10% of 10 half-sib families with 500 or 2,000 progeny on 6 equi-distant markers on a 100 cM chromosome with one QTL with effect 0.25 phenotypic SD. Two models were used for LSIM: LSIM-2 fitted two QTL frequencies per family, one for each tail, whereas LSIM-1 fitted only a single QTL frequency by

setting upper tail frequency = (1 - lower tail frequency). A Chi-square test was used for single marker analyses. Power was estimated from 3,000 replicates using empirical 5% chromosome-wise significance levels. Power was highest for LSIM-1, followed by the single marker analyses and lowest for LSIM-2. For 500 progeny and a QTL at 11 or 46 cM, power was 56 and 69% for LS-1, 51 and 55% for single marker analyses, and 35 and 55% for LSIM-2. Trends were the same with 2,000 progeny but all powers were >90%. LSIM-1 also resulted in more accurate and precise estimates of QTL location and effect than LSIM-2, but estimates of position were biased toward the center of the chromosome for both. Bias was greater when power was low and with the QTL at 11 cM. Similar bias was observed for the single-marker method. Results show that LSIM-1 is the preferred method to analyze selective DNA pooling data.

**Key Words:** Selective DNA Pooling, QTL Mapping

**18 Extended analysis of a Berkshire x Yorkshire cross to detect QTL for growth and meat quality traits.** H. Thomsen<sup>\*</sup>, M. Malek, J. C. M. Dekkers, and M. F. Rothschild, Iowa State University, Ames.

An experiment was initiated to identify QTL affecting growth, body composition, meat and muscle composition in a cross between Berkshire and Yorkshire breeds. A three-generation resource family was created by using two Berkshire grand sires and nine Yorkshire grand dams to produce nine litters of F1 individuals. Eight boars and 26 gilts were chosen to produce 65 litters with 527 F2 offspring. In total, 28 traits for meat quality and 12 traits for growth and body composition were measured in the F2 animals. All animals were initially genotyped for 125 markers across the genome, which resulted in over 100 QTL identified at a 5% chromosome-wise level. The objective of this study was to extend this scan by genotyping for another 33 markers in special regions of interest. New marker linkage maps were derived for all autosomes and the X chromosome and used in QTL analysis based on line cross least squares regression interval mapping. Sex and year-season were included as fixed effects. Litter size was used as a covariable for some traits. Significance thresholds were derived at a chromosome-wise and genome-wise level on a single-trait basis by using a permutation test with 10,000 shuffles of the original data. A total of 49 QTL were discovered for growth and composition traits, of which 10 were significant at a 1% genome-wise level and another 5 were significant at the 5% genome-wise level. QTL for growth and composition traits were located on chromosomes 1, 2, 4, 5, 7, and 9. For meat quality traits, 73 QTL were detected, of which 5 were significant at a 1% genome-wise level and 14 were significant at the 5% genome-wise level. QTL for meat quality were detected on chromosomes 1, 2, 6, 7, 10, 14, 15, and 18. Results from this study were in good agreement with findings from the initial analyses. However, the increase of markers in regions of interest revealed approximately 20 new QTL at the 5% chromosome-wise level, of which at least one QTL was significant at a genome-wise level of 5%. Twelve of the original QTL were no longer significant at the 5% chromosome-wise level. These findings confirm the segregation of important QTL for growth and meat quality traits between the Berkshire and Yorkshire breeds. This work was supported by CSREES IFAFS # 00-52100-9610

**Key Words:** QTL, Growth, Meat Quality

**19 Tests of candidate genes in QTL mapping populations.** H. H. Zhao<sup>\*</sup>, J. C. M. Dekkers, and M. F. Rothschild, Iowa State University, Ames.

In recent years, several F<sub>2</sub> breed cross populations have been developed to identify quantitative trait locus (QTL) regions. These populations are phenotyped for many traits and genotyped for many genetic markers and, therefore, provide a valuable resource for further genetic analysis, including analysis of candidate genes. Although an association study is a robust method to test candidate genes within a closed population, their analysis in an F<sub>2</sub> population is problematic, because of the extensive between-breed linkage disequilibrium (LD). The objective of this study was to develop statistical tests for candidate gene analysis in F<sub>2</sub> populations. An F<sub>2</sub> of 600 progeny was simulated. In order to generate LD within parental breeds between the QTL and candidate genes, two generations were added to produce F<sub>0</sub> parents. A 100 cM chromosome was simulated with 6 equi-distant markers, a QTL with an effect of 0.25 phenotypic SD, and 9 candidate genes with distances from the QTL ranging from 0-30 cM. Gene frequencies in parental breeds were chosen to produce various combinations of within- and between-breed LD. QTL

were detected by least squares interval mapping. Three candidate gene tests were evaluated: (1) An association test based on the fixed effect of the candidate gene, (2) An association test based on a model that included between-breed QTL effects, and (3) Comparison of F-statistics for a QTL at the candidate gene position with and without the candidate gene as fixed effect. Comparison of tests (1) and (2) showed that incorporating QTL effects in the model removed the confounding effect of between-breed LD. Although test (3) showed a drop in the F-statistic at the candidate gene position, the result was not very informative. Test (2) was found to be most suitable because it was closely related to within-breed LD between the candidate gene and QTL. Further studies are in progress to determine the power of test (2) to detect candidate genes that are tightly linked to the QTL. This work was supported by CSREES IFAFS # 00-52100-9610.

**Key Words:** QTL Mapping, Candidate Gene, Linkage Disequilibrium

## 20 Effect of using approximate gametic variance covariance matrices on marker assisted selection by BLUP. L.R. Totir\*, R.L. Fernando, and J.C.M. Dekkers, *Iowa State University.*

Henderson's mixed model equations (HMME) can be used for genetic evaluation by BLUP with marker and trait data. In order to accommodate large pedigrees it is convenient to include in the model, as a random effect, the gametic effect of the QTL linked to the markers (MQTL), in addition to the random additive genetic effect of the remaining QTL (RQTL). The inverses of the variance covariance matrices for the gametic effects at the MQTL and the genetic effects at the RQTL are required to construct HMME. Algorithms have been developed to obtain these inverses efficiently. When a single marker locus is used, the algorithm for inverting the gametic variance covariance matrix at the MQTL yields exact results when marker genotypes are observed for all parents. When flanking markers are used, the marker genotypes as well as the linkage phase between the flanking markers must be known to obtain exact results. In large pedigrees, however, incomplete marker information is the rule rather than the exception. Further, the linkage phase is very likely to be unknown for some parents. When genotype and phase information is missing, approximations must be used. When phase is missing, a common practice is to ignore the marker information completely. An alternative to this approach is to use only the information at one marker when phase is missing. The objective of this study is to examine the consequences of these approximations on accuracy of genetic evaluations. For small simulated data sets, response to selection by marker assisted BLUP using the two approximations was calculated for flanking markers with 2, 4 and 12 alleles. Greater response to selection was obtained with the second approximation in all situations considered so far. In subsequent research, the exact variance covariance matrix for the gametic effect will be obtained by Markov Chain Monte Carlo techniques, and response to selection on BLUP based on the exact matrix will be compared to response obtained from approximate matrices.

**Key Words:** Marker Assisted Selection, BLUP, Gametic Covariance Matrix

## 21 Trends in heritability of serially measured ultrasound ribeye area measures in Angus cattle. A. Hassen\*, D. E. Wilson, and G. H. Rouse, *Iowa State University, Ames.*

Serially measured ultrasound ribeye area (REA) measures from 675 purebred Angus bulls and heifers were used to evaluate general trend in heritability values. Cattle were born during the spring of 1998, 1999, and 2000 at the Rhodes beef research farm. Each year bulls and heifers were scanned four to six times for REA starting at a mean age of 36 weeks, with 4 to 6 weeks interval between scans. The objective of this study was to evaluate the general trend in variance component estimates and heritabilities of serially obtained REA measurements. REA observations across the three years were analyzed by scan session using a single-trait animal model. In further analysis, serial data pooled over the three year period were analyzed using random regression models (RRM) that included fixed effects of contemporary group and fixed linear regression on Legendre polynomials of age at measurement. Random effects considered were Legendre polynomials of age at measurement for animal direct genetic and animal permanent environmental effects. Heritabilities of REA for the first five scan sessions across years were 0.30 0.10, 0.35 0.10, 0.28 0.09, 0.41 0.10, and 0.31 0.18, respectively. These scans represented mean ages of 36, 41, 47, 52, and 54 weeks, respectively. Results from RRM analysis showed a general increase in heritability values

from a minimum of 0.26 at mean ages of 28 to 29 weeks to a maximum of 0.44 at mean ages of 61 to 63 weeks. A heritability value of 0.40 at 52 weeks of age was the same as the corresponding estimate from single trait analysis for scan session four (age = 52 weeks). The permanent environmental variance contributed up to 52% of the total phenotypic variance at earlier ages, followed by a constant decline until it reached a minimum of 38% at 63 weeks of age. The results suggest that individual selection for REA at earlier ages may not be effective due to a large contribution of non-genetic effects.

**Key Words:** Composition, Ultrasound, Heritability

## 22 Genetic parameters for sex-specific traits in beef cattle: mature weight of cows and carcass traits of steers. K. A. Nephaw<sup>1</sup>\*, L. V. Cundiff<sup>2</sup>, and L. D. Van Vleck<sup>3</sup>, <sup>1</sup>*University of Nebraska, Lincoln*, <sup>2,3</sup>*USDA, ARS, USMARC*, <sup>2</sup>*Clay Center, NE*, <sup>3</sup>*Lincoln, NE.*

Data from the first four cycles of the Germplasm Evaluation Program (USMARC) were used to estimate genetic parameters of and among female mature weights (n=37,710) and carcass traits of their steer paternal half-sibs (n=4,031). Female mature weights were available from four through eight years of age. Cows (n=1,801) were measured in four different seasons each year. Data were analyzed by REML. Estimates of heritability for mature weight (MW) and mature weight adjusted for body condition score (AMW) using repeatability models were 0.52 and 0.57, respectively. Estimates of heritability for hot carcass weight (HCWT), retail product percentage (RP%), fat percent (FAT%), bone percent (BONE%), rib eye area (REA), adjusted fat thickness (AFAT), estimated kidney, pelvic and heart percent (EKPH%), marbling score (MARB), Warner-Bratzler shear force (WBSF), taste panel flavor (TPF), taste panel juiciness (TPJ) and taste panel tenderness (TPT) measured on steers were 0.52, 0.59, 0.53, 0.52, 0.57, 0.46, 0.65, 0.46, 0.29, 0.05, 0.01 and 0.26, respectively. Estimates of genetic correlations between MW and HCWT, RP%, FAT%, BONE%, REA, AFAT, EKPH%, MARB, WBSF, TPF, TPJ and TPT were 0.81, -0.13, -0.07, 0.25, 0.34, -0.03, 0.00, -0.15, 0.15, 0.29, -0.32 and -0.20, respectively. Similar estimates were obtained between AMW and carcass traits. Genetic correlations between mature weight of cows and carcass traits also were estimated for mature weights analyzed separately by season of measurement and by age (in years). Estimates were consistent with overall data. Estimates of genetic correlations between mature weight and carcass composition or meat quality traits were relatively low. To change percentage retail product (or marbling or tenderness), direct selection for carcass and meat traits would be needed. Direct selection for most carcass and meat traits could be effective and would lead to only minor changes in mature weight.

**Key Words:** Genetic Correlations, Heritabilities, Body Condition Score

## 23 Effect of sire misidentification on estimates of genetic parameters for weaning weight. S. Senneke<sup>1</sup>\*, M. D. MacNeil<sup>2</sup>, and L. D. Van Vleck<sup>3</sup>, <sup>1</sup>*University of Nebraska, Lincoln*, <sup>2</sup>*USDA, ARS, LARRL, Miles City, MT*, <sup>3</sup>*USDA, ARS, USMARC, Lincoln, NE.*

This study was based on records of Line I Herefords collected at the Fort Keogh Livestock and Range Research Laboratory in Miles City, Montana. A total of 4,170 records between the years of 1935-1989 were available. Sires of progeny within year were randomly misidentified based on the number of progeny the sires contributed that year. Sire misidentification levels ranged from 5 to 50% with increments of 5%. For each level of sire misidentification 100 replicates were obtained. The misidentified data were then analyzed using single trait analyses with a REML algorithm. Two different models were used to analyze the data (Model 1 and Model 2). Both models contained year by sex and age of dam as fixed effects, julian birth date as a covariate, and animal and maternal genetic effects and maternal permanent environment as random effects. Model 2 also included sire by year as a random effect. Direct and maternal heritability decreased (0.20 to 0.03 and 0.16 to 0.05, respectively) as the level of misidentification increased using Model 1. However, the direct-maternal correlation increased from -0.38 to 0.38 as the fraction of misidentification increased. With Model 2, similar to Model 1, direct and maternal heritability decreased (0.17 to 0.03 and 0.15 to 0.05, respectively) as the level of misidentification increased. The direct-maternal correlation increased from -0.31 to 0.50

as the level of misidentification increased. Use of Model 2 caused estimates of the correlation to be more positive than with Model 1. As the level of misidentification increased, fraction of sire by year variance decreased, by a small amount, from 0.015 to 0.004. Results from this study indicate that sire misidentification may severely bias estimates of genetic parameters.

**Key Words:** Heritability, Direct-Maternal Correlation, Beef Cattle

**24 Genetic estimates of parameters for hip height at different ages for four lines of Hereford cows.** J. M. Rumph<sup>\*1</sup>, R. M. Koch<sup>1</sup>, K. E. Gregory<sup>2</sup>, L. V. Cundiff<sup>2</sup>, and L. D. Van Vleck<sup>2,3</sup>, <sup>1</sup>University of Nebraska, Lincoln, NE, <sup>2</sup>USDA, ARS, USMARC, <sup>2</sup>Clay Center, NE, <sup>3</sup>Lincoln, NE.

Measurements of hip height were recorded a maximum of three times per year for a control and three selection lines of spring calving Hereford heifers and cows: before calving (BC, n = 2,210), before breeding (BB, n = 3,231), and during weaning of calves and pregnancy checking via rectal palpation (PA, n = 3,435). The lines were selected for increased weaning weight, yearling weight, and an index of yearling weight and muscling score. Measurements were for yearling heifers through 10-year old cows. Based on the likelihood ratio test, a simple model that included only additive genetic and environment as random effects was determined to be sufficient. Fixed effects included were year x age x line and age of dam x line. When all ages were included in a repeatability model, heritability (standard error) was estimated to be 0.65 (0.02), 0.66 (0.02), and 0.70 (0.01) for BC, BB, and PA heights. With measurements from all three seasons together in a univariate analysis that included season x line as an additional fixed effect, the estimate of heritability was 0.60 (0.01). With ages analyzed separately, most estimates of heritability were greater than 0.50, but the small number of observations at older ages (> 7 yr) caused both the heritability estimates to be small and standard errors to be high relative to estimates for other ages. In bivariate analyses to estimate the correlation between heights at two ages within a season, most of the heritability estimates were greater than 0.50. Most estimates of genetic correlations were greater than 0.80. Hip height is a highly heritable trait that would respond to selection to alter mature size of the cow herd.

**Key Words:** Correlation, Heritability, Mature Size

**25 Genetic trends for mature weight for four lines of Hereford cows.** J. M. Rumph<sup>\*1</sup>, R. M. Koch<sup>1</sup>, K. E. Gregory<sup>2</sup>, L. V. Cundiff<sup>2</sup>, and L. D. Van Vleck<sup>2,3</sup>, <sup>1</sup>University of Nebraska, Lincoln, NE, <sup>2</sup>USDA, ARS, USMARC, <sup>2</sup>Clay Center, NE, <sup>3</sup>Lincoln, NE.

Mature weights (MW) were obtained a maximum of three times from a control (CTL) and three selection lines born over an 11-year period for 5-year-old spring calving Hereford cows. The seasons of measurement were before calving (BC), before breeding (BB), and during weaning of calves and pregnancy checking via rectal palpation (PA). The selection lines were selected for increased weaning weight (WWL), yearling weight (YWL), and an index of yearling weight and muscling score (IXL). Mature weights for each season were analyzed separately in bivariate analyses with birth weight (BW) or weaning weight (WW). The model for MW included fixed effects of year x age x line, age of dam x line, pregnancy status x line, and birth and method of rearing of calf x line. Random effects were direct genetic, maternal genetic, direct permanent environmental, maternal permanent environmental, and temporary environmental (residual). Based on the mean EBV by year of birth from analyses with birth weight for BC, direct EBV changed by 1.79, 1.45, 2.14, and -0.65 kg/yr for WWL, YWL, IXL, and CTL, respectively. For BB, maternal EBV changed by 0.21, 0.16, 0.18, and -0.06 kg/yr. For PA, direct EBV changed by 1.68, 1.62, 1.98, and -0.60 kg/yr and maternal EBV changed by 0.21, 0.16, 0.18, and -0.06 kg/yr. For PA, direct EBV changed by 2.13, 1.54, 2.38, and -0.67 kg/yr and maternal EBV changed by 0.21, 0.16, 0.18, and -0.06 kg/yr. Based on the mean EBV from analyses with weaning weight, BC for direct EBV changed by 1.50, 1.57, 1.63, and -0.23 kg/yr for WWL, YWL, IXL, and CTL, respectively and maternal EBV changed by 0.53, 0.53, 0.46, and -0.10 kg/yr. For BB, direct EBV changed by 1.37, 1.69, 1.35, and -0.17 kg/yr and maternal EBV changed by 0.57, 0.56, 0.48, and -0.10 kg/yr. For PA, direct EBV changed by 1.76, 1.72, 1.66, and -0.19 kg/yr and maternal EBV changed

by 0.55, 0.53, 0.48, and -0.09 kg/yr. Selection for increased weaning or yearling weights also increased breeding values for mature weight.

**Key Words:** Breeding Values, Mature Size, Selection

**26 Genetic parameters for lifetime production of Hereford cows.** G. E. Martinez<sup>\*1</sup>, R. M. Koch<sup>1</sup>, L. V. Cundiff<sup>2</sup>, K. E. Gregory<sup>2</sup>, and L. D. Van Vleck<sup>2,3</sup>, <sup>1</sup>University of Nebraska, Lincoln, NE, <sup>2</sup>USDA, ARS, USMARC, <sup>2</sup>Clay Center, NE, <sup>3</sup>Lincoln, NE.

Genetic parameters for number of calves born (NB), weaned (NW) and cumulative weaning weight (CW, kg) were estimated from 2,454 records of Hereford cows with opportunity to live to 3 to 7 yr of age, from a control line (CTL) and lines selected for weaning weight (WWL), yearling weight (YWL), and an index of yearling weight and muscle score (IXL) collected from 1964 through 1982. Weaning weights were adjusted for sex and age of dam. Estimates were obtained from bivariate animal models within trait (NB, NW and CW) for all pairs of opportunity groups (3 to 7 yr of age). Data were analyzed using REML with year of birth of the cow as a fixed effect and direct genetic and residual as random effects. Genetic trends were estimated by regressing means of estimated breeding values (EBV) by year of birth and line on birth year. Estimates of heritability (SE) for opportunity groups of 3 to 7 yr respectively were: 0.11 (0.03), 0.13 (0.04), 0.13 (0.04), 0.14 (0.03) and 0.13 (0.03) for NB; 0.15 (0.03), 0.15 (0.04), 0.11 (0.03), 0.15 (0.03) and 0.13 (0.03) for NW; and 0.11 (0.03), 0.14 (0.04), 0.13 (0.03), 0.13 (0.03) and 0.14 (0.03) for CW. Genetic correlations between opportunity groups ranged between 0.91 (0.01) and 1.00 (0.01). Estimates of genetic trend for cows with opportunity for 6 yr were: 0.00, 0.00, and 0.00 for NB/year; 0.00, 0.01, and 0.01 for NW/year; and 0.19, 0.90, and 0.48 kg for CW/year, for WWL, YWL, and IXL, respectively. Mean EBV for cows born in 1982 were: -0.03, -0.00, and 0.02 for NB; -0.00, 0.01, and 0.01 for NW; and 0.23, 1.38, and 1.11 kg for CW. Results suggest that selection for lifetime production measured by NB, NW or CW during a cow's lifetime could be effective but relatively slow due to low estimates of heritability and possibly prolonged generation interval. The high genetic correlations among opportunity groups indicate that cumulative records through 3 years of age predict subsequent cumulative records through 7 years of age.

**Key Words:** Genetic Correlation, Heritability, Selection

**27 Genetic parameters for longevity and lifetime production of Hereford cows.** G. E. Martinez<sup>\*1</sup>, R. M. Koch<sup>1</sup>, L. V. Cundiff<sup>2</sup>, K. E. Gregory<sup>2</sup>, and L. D. Van Vleck<sup>2,3</sup>, <sup>1</sup>University of Nebraska, Lincoln, NE, <sup>2</sup>USDA, ARS, USMARC, <sup>2</sup>Clay Center, NE, <sup>3</sup>Lincoln, NE.

Genetic parameters for longevity (LO, days between first calving and disposal date) and lifetime production (LT, weaning weight in kg of all calves weaned by disposal date) were estimated using records collected from 1964 to 1982 of 2,242 Hereford cows from a selection experiment with three lines selected for weaning weight (WWL), yearling weight (YWL), and an index of yearling weight and muscle score (IXL), and a control line (CTL). Weaning weights were adjusted for sex and age of dam. Heritabilities were estimated by REML using a bivariate animal model with year of birth of the cow (Y) as a fixed effect and direct genetic and residual effects as random. The genetic trends were estimated by regressing means of estimated breeding values (EBV) by year of birth and line on birth year. Estimates of heritability (SE) were: 0.14 (0.03) and 0.14 (0.03) for LO and LT, respectively. Estimated genetic correlation was 0.99 (0.05) and environmental correlation was 0.51 (0.02). Genetic trends were for LO 7.2, 8.7, and 7.5 days/year and for LT 3.4, 3.9, and 3.5 kg/year for WWL, YWL and IXL, respectively. The average EBV for cows born in 1982 were: 135.5, 145.1, and 132.4 days for LO and 63.0, 65.2, and 62.5 kg for LT, for WWL, YWL and IXL, respectively. These results suggest that selection for LO or LW could be successful in a breeding program, but relatively slow due to the low magnitude of heritability and possible extended generation interval. However, the favorable genetic trends for LO and LT indicate that selection for weights at relatively young weaning or yearling ages had a favorable effect on longevity and lifetime production without increasing the generation interval nearly as much as would be expected with selection for LO and LT directly.

**Key Words:** Genetic Correlation, Heritability, Selection

**28 Estimation of genetic parameters of lamb mortality using discrete survival analysis.** B. R. Southey<sup>\*1</sup>, S. L. Rodriguez-Zas<sup>1</sup>, and K. A. Leymaster<sup>2</sup>, <sup>1</sup>University of Illinois, Urbana, <sup>2</sup>USDA-ARS, U. S. Meat Animal Research Center, Clay Center, NE.

Lamb mortality from a composite population at the US Meat Animal Research Center was studied using discrete time survival analysis since the actual time of mortality may be unavailable, but information about a particular interval is available. Mortality records from 8,642 lambs were separated according to age into three stages, birth to weaning (BW), weaning to 365 d of age (WY) and birth to 365 d of age (BY). Within each stage, animal-period records were constructed with period defined as weekly or fortnightly. In addition, a daily animal-period was studied for BW and a monthly animal-period was studied for WY and BY. The logistic and complementary log-log link functions were used in sire, animal, and animal and maternal effects models and compared to continuous time survival Weibull model. The estimates of the sire variance were very similar between link functions and length of animal-period in all stages and to estimates obtained using the Weibull sire model. The complementary log-log link function heritabilities (standard errors) were 0.18 (0.06), 0.20 (0.20) and 0.13 (0.04) for BW, WY and BY stages, respectively, and were very similar to those obtained using a Weibull sire model. However, these estimates were approximately twice the magnitude of the estimates obtained with a logistic link function. These differences are probably due to the different variances of the link functions. Estimates of additive genetic variance and the associated heritability obtained with animal or animal and maternal effects models were lower than the sire model for the same scenario. These results illustrate that the use of discrete time approaches constitutes a feasible alternative to continuous time approaches in survival analysis.

**Key Words:** Sheep, Frailty, Proportional Hazards

**29 Comparison of models for traits of Rambouillet sheep.** L. D. Van Vleck<sup>\*1</sup>, K. J. Hanford<sup>2</sup>, and G. S. Snodder<sup>3</sup>, <sup>1</sup>USDA, ARS, USMARC, Lincoln, NE, <sup>2</sup>University of Nebraska, Lincoln, <sup>3</sup>USDA, ARS, USSES, Dubois, ID.

Several analytical models for birth weight (BWT, 17, n = 35,604), weaning weight (WWT, 11, n = 34,114), fleece weight (FWT, 8, n = 38,113) and number born (NB, 8, n = 39,029) were compared for Rambouillet sheep born at the USSES (1950-1998). For BWT, direct and maternal heritability were 0.26 and 0.19 (correlation of about zero) for all models. Likelihoods for models that also included dam by year, dam by number born, and sire by dam effects were significantly better than the basic maternal effects model, accounting for 0.06, 0.04, and 0.03 of phenotypic variance, respectively. Effects of cytoplasmic line and sire by cytoplasmic line were not significant. For WWT, direct and maternal heritability were 0.18 and 0.10 with correlation of 0.31 between direct and maternal genetic values. Of the other effects, only maternal permanent environmental effects (0.05 of variance) was not zero. For FWT, direct heritability was 0.55 for all models, but estimates of relative variance due to dam by year (0.02), sire by dam (0.05), and sire by cytoplasmic line (0.02) were jointly significant compared to a model with permanent environmental effects. For NB, for all models only direct heritability (0.08) and relative permanent environmental variance (0.04) were not zero. None of the traits showed evidence of variation due to cytoplasmic effects. Adding seldom considered effects to the model did not change estimates of variance due to direct and maternal genetic effects for any trait. Variance due to dominance effects inferred from estimate of the sire by dam component of variance may be important for BWT and FWT. The basic direct-maternal effects model seems sufficient for genetic evaluations for WWT and FWT but models for BWT and NB may need to include other effects. Variation due to these effects seems to be partitioned primarily from variation due to animal permanent environment effects for FWT but for BWT about 0.10 more of total variance is accounted for by the model with dam by year, dam by number born, and sire by dam interaction effects.

**Key Words:** Birth Weight, Weaning Weight, Fleece Weight

**30 Genetic parameters for subjective milk score and litter weight for Targhee, Columbia, Rambouillet, and Polypay Sheep.** R. Sawalha<sup>\*1</sup>, J. F. Keown<sup>1</sup>, G. D. Snodder<sup>2</sup>, and L. D. Van Vleck<sup>3</sup>, <sup>1</sup>University of Nebraska, Lincoln, <sup>2</sup>USDA, ARS, U.S. Sheep Experiment Station, Dubois, ID, <sup>3</sup>USDA, ARS, U.S. Meat Animal Research Center, Lincoln, NE.

Genetic parameters for subjective milk score (MS) and litter weight at 70 days (LW) were estimated independently by breed. Data collected from 1990 to 2000 at the U. S. Sheep Experiment Station were analyzed with an animal model using REML. Number of records was 13,900 for 5,807 ewes. Records were grouped according to parity as: first, second, third and greater, and all records. Single and two trait analyses resulted in similar genetic parameter estimates within a trait. Estimates of heritability for MS by parity ranged from 0.05 to 0.18 for first, 0.01 to 0.27 for second, 0.05 for Targhee and 0.10 for the other breeds for mature MS and from 0.08 to 0.13 for all records. Milk score at first and second parities was highly correlated genetically; estimates ranged from 0.74 to 1.00. Similarly, MS at first and second parities were highly genetically correlated with mature MS. Consequently, additive genetic milking ability at maturity could be evaluated as early as first parity. Heritability estimates for LW ranged from 0.00 to 0.18 for all breeds and parity groupings. Genetic correlation estimates at first parity between MS and LW were high (1.00) for Rambouillet and Polypay; moderate for Targhee (0.27) but near zero for Columbia (-0.02). At second parity, estimates were more variable and ranged from -1.00 to 1.00. For mature records, estimates ranged from -0.28 to 0.84. For all records, estimates were positive and moderate for all breeds (0.15 to 0.68). Estimates of genetic correlation between LW at first or second parity with mature LW were mostly high and positive except for Targhee (-0.10) and Polypay (0.14) at first parity. Litter weight for mature ewes could be improved by selection at first or second parity. Although estimates are variable, the average genetic correlation suggests that LW can be improved by selecting ewes for favorable milk scores.

**Key Words:** Heritability, Genetic Correlations, Breeds

**31 Genetic parameters for growth, feed intake, and feeding behavior in a composite population of sheep.** K. M. Cammack<sup>\*1</sup>, M. K. Nielsen<sup>1</sup>, K. A. Leymaster<sup>2</sup>, and T. G. Jenkins<sup>2</sup>, <sup>1</sup>University of Nebraska, Lincoln, <sup>2</sup>U.S. Meat Animal Research Center, Clay Center, NE.

The objective of this study was to estimate genetic parameters for growth, feed intake, and feeding behavior in composite rams (\*Columbia, \* Hampshire, \* Suffolk). Data were collected from 1986 to 1997 in Pinpointer units on 1,241 rams from 10 to 17 wk of age. Each Pinpointer unit was an elevated pen with an entrance chute that permitted feeder access for only one ram at a time with disappearance of feed measured electronically. Rams were grouped 11 per pen in 1986 through 1989, and 9 per pen in 1990 through 1997. Data were edited to exclude invalid feeding events. Approximately 80% of the feeding records remained after edits were applied. Estimated direct and maternal heritabilities for initial weight (weight0) were 0.34 and 0.30, respectively. The correlation between direct and maternal genetic effects was -0.88. Average daily gain (ADG) was estimated using three separate sets of data and heritability estimates ranged from 0.27 to 0.29. Results indicated that recording body weight at only the initiation and conclusion of a testing period is sufficient to accurately measure ADG and estimate genetic parameters. Estimated heritability of daily feed intake (DFI) was 0.23. Heritability estimates for number of feeding events per day (NE) and daily feeding time (DT) were 0.33 and 0.24, respectively. Feed efficiency had an estimated heritability of 0.15. Genetic correlations were positive between growth, feed intake, and feeding behavior traits. Phenotypic correlations were generally similar to genetic correlations. Direct genetic correlations were high (0.80) between ADG and DFI; intermediate (0.27 to 0.55) between DFI and DT, DFI and NE, ADG and NE, and NE and DT; and low (0.10 to 0.19) between ADG and weight0, DFI and weight0, and ADG and DT. Results suggest that selection for indices of ADG and DFI will likely change feeding behavior.

**Key Words:** Feeding Behavior, Feed Intake, Genetic Parameters



### 32 Genetic parameters and responses to nine generations of selection to increase litter size in swine. J. W. Holl\* and O. W. Robison, *North Carolina State University, Raleigh.*

Nine generations of direct selection for increased litter size were practiced. The select line consisted of approximately 15 sires and 75 dams per generation. Selection was based on estimated breeding values for number of live pigs. A control line of approximately 10 sires and 25 dams was maintained with stabilizing selection. Heritabilities estimated from REML procedures, daughter-dam regression within sires, and half-sib analysis were 0.01, 0.04, and 0.00 for number of pigs born alive (NBA); 0.02, 0.16, and 0.00 for total born per litter (TB); 0.17, 0.09, and 0.27 for backfat thickness adjusted to 104 kg (BF); and 0.50, 0.35, and 0.56 for days to 104 kg (DAYS), respectively, for the select line. Corresponding estimates for the control line were 0.01, 0.06, and 0.23; 0.02, 0.07, and 0.09; 0.27, 0.10, and 0.40; and 0.43, 0.28, and 0.43, respectively. Using weighted multiple regression, heritability estimates for NBA were  $0.09 \pm 0.075$  for select and  $0.11 \pm 0.156$  for control lines. Regression of difference of response between lines on cumulative selection differentials yielded a heritability estimate of  $0.13 \pm 0.07$ . At Generation nine, the select line exceeded the control line by 0.86 pigs ( $P > 0.05$ ). Estimated breeding values differed between the lines by 0.63 for NBA ( $P < 0.01$ ) and cumulative selection differential for NBA differed by 9.05 ( $P < 0.01$ ). Differences between the lines for TB, BF, and DAYS were not significant. Genetic trends in the select line were  $0.053 \pm 0.002$  pigs/yr for NBA,  $0.054 \pm 0.013$  mm/yr for BF, and  $0.398 \pm 0.113$  days/yr for DAYS. Corresponding phenotypic trends were  $0.144 \pm 0.053$  pigs/yr,  $-0.012 \pm 0.087$  mm/yr, and  $0.307 \pm 0.278$  days/yr, respectively. Genetic trends in the control line were  $-0.026 \pm 0.004$  pigs/yr for NBA,  $0.026 \pm 0.023$  mm/yr for BF, and  $-0.532 \pm 0.166$  days/yr for DAYS. Corresponding phenotypic trends were  $0.001 \pm 0.079$  pigs/yr,  $-0.043 \pm 0.153$  mm/yr, and  $-0.519 \pm 0.463$  days/yr, respectively.

**Key Words:** Pigs, Selection, Litter Size

### 33 Genetic parameters for primal cut weights in pigs. D. W. Newcom<sup>\*1</sup>, T. J. Baas<sup>1</sup>, and R. N. Goodwin<sup>2</sup>, <sup>1</sup>Iowa State University, Ames, <sup>2</sup>National Pork Board, Des Moines, IA.

The objective of this study was to estimate genetic parameters for primal cut weights in pigs. Carcass and dissection data from 456 Halothane negative, purebred Yorkshire, Duroc and Other breed pigs with three generation pedigrees were analyzed to estimate heritabilities and genetic correlations. The traits of interest were the primal cuts of Ham 401 (HAM), Loin 410 (LOIN), Boston Butt 406 (BB), Picnic 405 (PIC), and Belly 409 (BELLY) cut to Institutional Meat Purchase Specifications (IMPS). With a lack of previous literature estimates for these traits, 10<sup>th</sup> rib backfat (BF10) and loin muscle area (LMA) were included as reference traits. A multiple trait animal model was performed using MTDFREML to estimate additive genetic (animal) and residual variances and covariances. The model included the fixed effects of breed, sex and group with off-test weight as a covariate. Heritability estimates for HAM, LOIN, and BELLY weights were higher than expected, however BF10 and LMA were well within the range of previous literature estimates ( $h^2 = 0.58$  and  $0.69$ ). BB and PIC were both found to be lowly heritable traits. Genetic correlations were generally high with BF10 and BELLY showing a positive correlation with one another and a negative association with LMA and the four lean cuts. The four lean cuts were all positively correlated with each other and with LMA. Results from the seven trait primal analysis are shown below.

	HAM	LOIN	BB	PIC	BELLY	BF10	LMA
HAM	0.61	0.60	0.37	0.74	-0.62	-0.64	0.57
LOIN		0.63	0.76	0.88	-0.59	-0.64	0.80
BB			0.09	0.79	-0.66	-0.14	0.54
PIC				0.20	-0.76	-0.62	0.81
BELLY					0.67	0.61	-0.40
BF10						0.58	-0.57
LMA							0.69

Heritabilities on diagonal, Genetic correlations above diagonal

**Key Words:** Pigs, Genetic Parameters, Primal Cuts

### 34 Two Pit-1 RFLPs and their association with growth traits in beef cattle. Q. Zhao\*, M.E. Davis, and H.C. Hines, *The Ohio State University, Columbus.*

Pit-1 is a pituitary specific transcription factor that has been shown to positively regulate the expression of growth hormone, prolactin, and thyrotrophin b subunit (TSH-b). Therefore, it may be a good candidate gene for genetic markers for growth traits. Growth traits have been shown to be under control of multiple genes, and genetic marker information on these genes can be used to facilitate selection and breeding through marker assisted selection (MAS) in domestic animals. Two highly linked polymorphisms were found in introns 3 and 4 of the Pit-1 gene. The intron 3 polymorphism was examined in 121 and the intron 4 polymorphism in 86 Angus beef cattle, which were divergently selected for high or low blood serum IGF-I concentration. The genotypic frequencies were 0.09 for CC, 0.49 for CD, and 0.42 for DD for the intron 3 polymorphism. Frequencies for the EE, EF and FF genotypes of the intron 4 polymorphism were 0.08, 0.56, and 0.36, respectively. The intron 3 polymorphism was shown to have an AAT deletion in allele C, which can be recognized by digestion with restriction enzyme Hinf-1. The intron 4 polymorphism has a G to T transition in allele F, which can be recognized by digestion with restriction enzyme BstNI. The associations of the polymorphisms with growth traits and IGF-I concentration were also analyzed using the GLM procedure in SAS. A linear model was fitted for birth weight, weaning weight, preweaning gain, on-test weight, weight at d 28 and 56 of the 140-d postweaning test, off-test weight, postweaning gain, serum IGF-I concentration on d 28, 42, and 56 of the postweaning test, and mean serum IGF-I concentration. No significant associations were found between the Hinf-1 genotypes and growth or IGF-I traits. A moderate association with on-test weight ( $P = .09$ ) was observed. Calves with genotype CD tended to have higher on-test weights than CC and DD calves. No significant relationships of the BstNI genotypes with growth traits or IGF-I concentrations were observed.

**Key Words:** Pit-1, Growth, Beef Cattle

### 35 Comparison of the glycolytic potential and DNA-based test for predicting Rendement Napole genotype. D. N. Hamilton<sup>\*1</sup>, M. Ellis<sup>1</sup>, K. D. Miller<sup>2</sup>, F. K. McKeith<sup>1</sup>, A. D. Higgerson<sup>1</sup>, and J. E. Beever<sup>1</sup>, <sup>1</sup>University of Illinois at Urbana-Champaign, <sup>2</sup>Elanco Animal Health, Greenfield, Indiana.

This study was carried out to evaluate the relationship between the phenotypic method (glycolytic potential) and the DNA-based test to determine Rendement Napole (RN) genotype. Glycolytic potential (GP) was determined on live-animal biopsy ( $n=161$ ) or postmortem longissimus samples ( $n=90$ ) to predict the RN genotype and a PCR-RFLP based test was used to determine the RN genotype. Prediction of RN genotype was on the basis of the breakpoint between the two parts of the bimodal frequency distribution for GP. The breakpoints in the distributions for the population in which GP was measured on live-animal and postmortem samples were 190 or 158  $\mu\text{mole/g}$ , respectively; animals with GP's below these values were classified as homozygous normal ( $\text{RN}^+\text{RN}^+$ ) and those with GP's above these values were classified as carriers ( $\text{RN}^-\text{RN}^+$ ). Longissimus GP was higher for carrier compared to homozygous recessive animals ( $242.6 \pm 52.11$  vs  $168.2 \pm 30.97$   $\mu\text{mole/g}$  and  $185.7 \pm 47.36$  vs  $118.6 \pm 18.36$   $\mu\text{mole/g}$  for the live-animal and postmortem samples, respectively;  $P < 0.05$ ). Only carrier and homozygous recessive animals were identified using the DNA test. Predicting genotype on the basis of GP resulted in 12.5 % of animals being mis-classified compared to the DNA test. There was a trend ( $P = 0.07$ ) for greater agreement between the two tests when genotype prediction was based on postmortem compared to live-animal samples (8.9 vs 18.3 % mis-classified, respectively). The percentage mis-classified was similar ( $P > 0.05$ ) for carrier and homozygous recessive animals (14.4 vs 11.1 %, respectively). Eight (29.6 %) of the 27 mis-classified samples were within 5  $\mu\text{mole/g}$  of the breakpoint value used to predict genotype; the remainder of the mis-classified samples were distributed across the range of GP values. Results from this research suggest that predicting RN genotype on the basis of muscle GP will result in a relatively limited number of mis-classifications.

**Key Words:** Rendement Napole, Glycolytic Potential, Pigs

**36 Study of factors influencing sow longevity in swine breeding herds.** S. L. Rodriguez-Zas<sup>\*1</sup>, B. R. Southey<sup>1</sup>, R. V. Knox<sup>1</sup>, and J. F. Connor<sup>2</sup>, <sup>1</sup>University of Illinois at Urbana-Champaign, <sup>2</sup>Carthage Veterinary Service, Ltd.

Early removal of sows from the herd due to mortality, health problems and poor performance is a major bottleneck in the swine industry. This situation amounts to animal welfare and economic concerns due to lower productivity, replacement and veterinary treatment costs. The goal of this study was to study sow longevity and production determinants and their interplay. Over 17,000 sow-parity longevity and production records obtained between 1993 and 2001 were studied. Complementary indicators of longevity including the parity and age, total number and weight of piglets (born alive, weaned) at removal or death were evaluated. Survival analysis, in the form of a linear proportional hazards model, was applied to the different measures of sow longevity. Sow productivity indicators across parities were analyzed using a repeated measurement model. The explanatory variables included parity, age, year, genetic line and sow specific removal reasons. A sow had an 81% probability to remain in the herd until the end of the first parity and this probability dropped to 50% after the fourth parity. Reproductive failure was the major removal cause in the first two parities. The probability of a sow remaining in the herd until the first parity was 88% when only reproduction failure was considered. Health, death, and locomotor problems were critical limiting factors of sow longevity in the later parities. Genetic line was a significant factor contributing to sow longevity. Assuming 2.35 parities per year and four parities to cover the replacement cost, the difference in the probability of survival to 620 d between the two most extreme genetic lines was 45%. Year and month of farrowing, parity and genetic line have significant effects on litter size. The ranking of the genetic lines in terms of longevity probability did not entirely correspond to that based on productivity. Results from this study suggest that culling policies together with genetic line must be considered in sow longevity and productivity improvement programs.

**Key Words:** Survival Analysis, Lifetime Production, Proportional Hazards

**37 Introgression of multiple QTL with limited population size in livestock.** N. Chaiwong<sup>\*</sup> and J. Dekkers, *Iowa State University, Ames.*

Genetic markers can be used to introgress favorable alleles at one or more quantitative trait loci (QTL) from a donor to a recipient breed through marker-assisted introgression (MAI). Current MAI programs require selected backcross individuals to be heterozygous for all QTL. This requires large numbers of backcross progeny to be produced, which is not feasible in livestock, in particular when QTL positions are not well known and several sizeable QTL regions must be introgressed. Furthermore, heterozygosity at all QTL is not required if the objective is to introduce favorable QTL alleles in the recipient breed for further genetic improvement. The objective of this study was to evaluate the potential for MAI of multiple QTL in a population of limited size. Backcross generations of 500 individuals were simulated and 100 individuals were selected per generation for backcrossing to the recipient breed. Selection was on the expected number of recipient QTL alleles carried by the individual at three unlinked QTL. Two cases were considered: known QTL and QTL regions marked by six informative markers in a 21 cM region centered around the QTL. For known QTL, selection was on observed QTL genotypes. For marked QTL regions, selection was on the number of intact marker intervals inherited from the donor breed, weighted by the probability of presence of a QTL in each interval. Weights were 0.1 for the external marker intervals, 0.2 for internal intervals, and 0.4 for the central interval. Effectiveness of MAI was evaluated based on the average frequency of favorable QTL alleles after five generations of backcrossing. Results for the known QTL case, which are based on a single replicate, showed a gradual decrease in average frequencies of donor QTL alleles from 0.5 in the F1 to 0.35 in the 5<sup>th</sup> backcross generation. Similar results were obtained for the marked QTL case, but further replication is needed to verify these results. Nevertheless, these preliminary results show that MAI of multiple QTL within a population of limited size can result in the introduction of donor QTL alleles into the recipient breed at reasonable frequencies that would allow subsequent within-breed improvement. This work was supported by CSREES IFAFS # 00-52100-9610.

**Key Words:** QTL, Marker-Assisted Introgression, Backcross

**38 Confirmation of quantitative trait loci (QTL) affecting body weight and fatness in a congenic line of mice.** N. Jerez-Timaure<sup>\*1</sup>, D. Pomp<sup>1</sup>, and E. J. Eisen<sup>2</sup>, <sup>1</sup>University of Nebraska-Lincoln, Lincoln, <sup>2</sup>North Carolina State University, Raleigh.

Understanding the genetics and physiology of growth and obesity is important in both animal production and human medicine. Fine-scale mapping of QTL using congenic lines provides a significant shortcut to the ultimate goal of gene positional cloning and identification. To isolate and examine a QTL with large effect on murine growth and fatness on distal chromosome 2 (MMU2), a congenic line was produced. The congenic line (MC) was created using the polygenically obese M16i selection line as the recipient for a 24 cM region (encompassing the broad QTL peak) from the inbred line C57BL6/J. Following 8 generations of marker-assisted introgression, the region was fixed by inter-se mating. We have compared M16i and MC for a variety of relevant phenotypes at three ages (6, 15, 24 wk) and on two diets (normal, high fat). M16i mice gained more weight than MC (significantly different up to 12 week of age), with no differences in feed intake at any stage. As a result of an improved feed efficiency, M16i mice fed with either diet were heavier than MC mice. The greatest differences in body composition between MC and M16i were detected at 15 weeks of age; M16i mice had more ( $P<0.05$ ) epididymal fat (2.79% vs. 1.17%) and total lipids (23.3% vs. 16.1%) than MC. Reduction in plasma leptin, insulin and glucose levels were observed ( $P<0.05$ ) in MC compared to M16i. Obesity of M16i was not diet-dependent. The differences detected between M16i and MC confirm the large effects of QTL in this region of MMU2 and support the use of MC for fine mapping. A large F<sub>2</sub> population using MC and M16i was developed to increase QTL map resolution. Synergistic strategies such as recombinant progeny testing and candidate gene expression are in progress to pinpoint the location of the QTL. The combination of these strategies will facilitate positional cloning of genes affecting fatness and growth.

**Key Words:** QTL, Congenic, Fatness

**39 Birth weight, calving ease, and other factors affecting perinatal mortality in Holstein cattle.** J. M. Johanson<sup>\*</sup> and P. J. Berger, *Iowa State University, Ames.*

Birth weights of Holstein cattle are rarely recorded, so the effect of birth weight on perinatal mortality has been difficult to determine. This research explores the effect of birth weight and other factors on perinatal mortality. The Iowa State University dairy research farm in Ankeny, IA collected 5,166 records of births between 1968 and 1999. The frequency of perinatal mortality was 9.8%. Due to the binary nature of the observations, the logistic regression model was used to predict perinatal mortality. The model included effects of year of birth, sex of calf, calving ease (unassisted or assisted), age within parity, birth weight, and gestation length. All factors were significant except sex of calf and age within parity. Odds ratio estimates were 1.014 for year, 1.156 for male versus female calves, and 3.897 for assisted versus unassisted births. The age within parity odds ratio estimates were 0.9878, 0.9779, 0.9855, and 0.9889 for parities 1 through 4 and greater, respectively. Birth weight and gestation length were fit as quadratic factors. Probabilities of perinatal mortality for birth weights 27, 33, 40, 46, and 52 kg were 3.2, 1.8, 1.5, 2.1, and 4.5%, respectively, when other factors were set at the average value. Similarly, gestation length of 267, 272, 278, 284, and 290 d yield probabilities of mortality of 3.2, 2.0, 1.6, 1.5, and 1.6%, respectively.

**Key Words:** Birth Weight, Perinatal Mortality, Holstein

**40 Differences in performance between growing pigs fed using electronic versus commercial feeders.** D.S. Casey<sup>\*</sup> and J.C.M. Dekkers, *Iowa State University, Ames.*

Single-space electronic feeders are increasingly used to measure feed intake on group-housed pigs in breeding herds, whereas multi-space feeders are used in commercial herds. The objective of this study was to evaluate the effect of electronic feeders on performance of Yorkshire boars and gilts during the growing period. Littermate Yorkshire boars and gilts ( $n=475$ ) were randomly assigned to pens with single-space FIRE<sup>®</sup> feeders and pens with 5-hole Smidley<sup>®</sup> feeders. At the beginning and end of test, pigs were weighed (mean 39 and 116 kg) and loin muscle area and backfat thickness were measured using real-time ultrasound.

Amount of feed consumed by each pen (n=39) was measured and average daily feed intake (ADFI) per pig for each pen was calculated. The traits average daily gain (ADG), backfat thickness (BF) and loin muscle area (LMA) at the end of test, difference in backfat thickness (DBF) and loin muscle area (DLMA) between the beginning and end of test, ADFI, and feed conversion ratio (FCR) were analyzed with a model that included the fixed effects of feeder type, sex, feeder type by sex interaction, and group (based on beginning test date, n=7) and the covariates weight at the end of test and floor space per pig. Weight at the beginning of test was used as an additional covariate for all traits except for BF and LMA. Feeder type had no significant effect ( $P < .05$ ) on any trait except on ADFI and FCR. Pigs on electronic feeders used less feed (-0.086 kg/day) and converted feed more efficiently (-0.085 kg feed/kg gain). Feeder type by sex interaction was significant only for ADG. Gilts grew slower on electronic feeders (-0.024 kg/day), whereas no feeder differences were found for boars. Significant sex differences were found for all traits except for DBF and ADFI. For all traits, group was significant and floor space per pig was not significant. In conclusion, the use of electronic feeders has no effect on growth performance, but does result in slightly lower feed usage, which could be explained by decreased feed wastage in electronic feeders.

**Key Words:** Swine, Electronic Feeder, Performance

**41 Effects of Rendement Napole gene and HAL 1843 gene on fresh and cooked pork loin quality.** R. N. Goodwin<sup>\*1</sup>, T. J. Baas<sup>2</sup>, K. Prusa<sup>2</sup>, C. Fedler<sup>2</sup>, and D. Newcom<sup>2</sup>, <sup>1</sup>National Pork Board, Des Moines, IA, <sup>2</sup>Iowa State University, Ames.

The HAL 1843 gene (N,n) and the Rendement Napole gene (rn+,RN-) are known to be major genes influencing pork carcass composition and pork meat quality. There were 1,202 tested progeny pigs, 654 barrows and 548 gilts, representing eight pure breeds. The 1999, 2000 and 2001 National Barrow Show Sire Progeny Test pigs were classified by HAL 1843 (1,127 NN, 75 Nn) and Rendement Napole (1,135 rn+rn+, 67 RN-rn+) genotype. Each sire group of eight pigs represented at least three litters. The loin was scored for color (PC), marbling (PM) and firmness (PF) and ultimate pH (pH) was measured. Light reflectance (MINP) and Hunter L score (HUNTP) were measured with a Minolta 310 Chromameter using a 50 mm orifice. Forty-eight hours post mortem the loin was divided into three chops. Water holding capacity (WHC) was measured using the filter paper method. The tenth rib chop was used for total lipid analysis (IMF). The eleventh and twelfth rib chops were aged for seven days, not frozen. Chops were cooked to 70 C and evaluated for cooking loss (CLOSS), star probe pressure (INSTRON), sensory panel juiciness score (JUICY), and sensory panel tenderness score (TENDER). A mixed linear model was used for data analysis. Fixed effects were date of slaughter, breed of pig, sex of pig, HAL 1843 genotype of pig, and Napole genotype of pig. Random effect was sire within breed. Table 1. Least squares means and standard errors.

Trait	Units	Napole normal, rn+rn+	Napole mono RN-rn+	Signif P<.05
PH	pH	5.72 .015	5.48 .025	*
MINP	percent	25.8 .29	27.7 .49	*
HUNTP	L score	50.6 .29	52.6 .48	*
PC	1-6 score	3.1 .07	2.5 .11	*
PM	Est %	2.1 .08	1.7 .13	*
PF	1-5 score	2.2 .04	1.8 .08	*
IMF	percent	2.32 .084	2.10 .130	.08
WHC	mg loss	59 1.8	89 3.2	*
CLOSS	percent	22.5 .34	25.4 .60	*
INSTRON	kg	5.95 .091	5.57 .151	*
JUICY	1-10 score	5.3 .12	5.6 .22	NS
TENDER	1-10 score	6.0 .13	6.9 .23	*

**Key Words:** Pig, Genetics, Pork Quality

**42 Fertility of intra-uterine vs. intra-cervical insemination of semen in swine.** T Gall<sup>\*</sup>, *Pork Technologies, Danville, IA.*

New technology has been developed that permits intra-uterine insemination of swine semen (IUI) as opposed to the current technique of intra-cervical insemination (ICI). Three hundred multiparous sows were

used in a paired study to determine the fertility of a low dose intra-uterine insemination compared to an industry standard conventional AI. Following weaning, estrus detection was performed and confirmed in the presence of a mature boar. Sows detected in estrus were paired according to parity, lactation length, number of pigs weaned and wean-estrus interval, randomly assigned to treatment and moved to breeding stalls. Forty-five minutes after estrus detection, an individually sterilized, disposable spiral tipped catheter with an inner canula (Soft Quick) was passed through the vagina and locked into the cervix of each IUI sow (n = 150), and 30 ml of extender at 43°C were inseminated intra-cervically. Two minutes following extender insemination, the inner canula was passed through the cervix into the uterine body and an 18 ml dose of semen ( $6.2 \times 10^8$  viable sperm) was inseminated via the inner canula. Following mating of IUI sows, a boar was introduced and the ICI sows (n = 150) were inseminated intra-cervically with a 75 ml dose of semen ( $3 \times 10^9$  viable sperm) from the same pool of boars using a disposable spiral tipped catheter. Sows were mated once each day until estrus was no longer observed. Nine ICI and 5 IUI sows were excluded from data analysis (provided by W.L. Flowers, NCSU, Raleigh, NC) due to culling, abortion or death. ANOVA was determined using the GLM procedure in SAS (v8.0, SAS, Cary, NC). Farrowing rate, average total pigs born and born alive were similar between IUI and ICI treatments (86.2% vs. 85.1%,  $10.8 \pm .3$  vs.  $11.2 \pm .3$ , and  $9.9 \pm .3$  vs.  $10.1 \pm .3$ ; respectively). Parity, breeding group and sire interactions with treatment were not detected. These results suggest that reproductive performance can be maintained with a reduced number of sperm using this IUI delivery system.

**Key Words:** Swine, Semen, Intra-Uterine Insemination

**43 Growth and puberty traits of topcross heifer progeny of Hereford, Angus, Red Angus, Simmental, Gelbvieh, Limousin, and Charolais sires.** L. V. Cundiff<sup>\*1,2</sup>, L. D. Van Vleck<sup>1,3</sup>, and R. M. Thallman<sup>1,2</sup>, <sup>1</sup>USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, <sup>2</sup>Clay Center, NE, <sup>3</sup>Lincoln, NE.

Data were obtained on 698 heifers born in the spring of 1999 and 2000 resulting from artificial insemination matings of Hereford (H, 21 sires), Angus (A, 22), Red Angus (Ra, 21), Simmental (S, 20), Gelbvieh (G, 23), Limousin (L, 20), and Charolais (C, 22) bulls, to Hereford, Angus, and composite MARC III (1/4 each Angus, Hereford, Red Poll, and Pinzgauer) cows. Data on 550-d weight, (550WT) 550-d height (550HT), frame score (FS as defined by Beef Improvement Federation), weight at puberty (PUBWT), age at puberty (PUBAGE), and pregnancy rate at 18 months (PREG) were analyzed by least squares procedures using a model that included random effects for sire in sire breed and fixed effects for sire breed, dam breed, sex of calf, age of dam (4.5,...10 yr), birth year, and sire breed x dam breed. Effects of sire breed were not significant ( $P > 0.05$ ) for PREG, but were significant for 550WT, 550HT, FS, PUBWT, and PUBAGE. Least squares means for H, A, Ra, S, G, L, and C sire progeny were 431, 424, 432, 436, 418, 423, and 431 kg, respectively for 550WT with a mean least significant difference (LSD,  $P < 0.05$ ) of 15 kg. Corresponding sire breed means were 128.4, 127.2, 126.9, 130.2, 128.8, 129.9, and 129.5 cm for 550 HT (LSD,  $P < 0.05$ , 1.6 cm); 5.5, 5.3, 5.3, 5.9, 5.6, 5.8 and 5.8 for FS (LSD,  $P < 0.05$  = 0.3 score units); 333, 340, 338, 344, 323, 356, and 344 kg for PUBWT (LSD,  $P < 0.05$  = 16 kg); 357, 343, 342, 342, 329, 377, and 358 d for PUBAGE (LSD,  $P < 0.05$  = 16 d), and 94, 88, 91, 90, 83, 87, and 91% for PREG (LSD,  $P < 0.05$ , 13%). Means for 550HT and FS were significantly greater for heifers with S, C, L, and G sires than those with A and Ra sires. PUBAGE was greater in L sired heifers than those by any other sire breed.

**Key Words:** Beef Cattle, Breeds, Germplasm

**44 Economic analysis of selection response in the NE Index line estimated in pure line and crossbred litters.** D. Petry<sup>\*</sup>, B. McAllister, and R. Johnson, *University of Nebraska, Lincoln.*

Economic effects of 19 generations of selection for litter size in the NE Index line were estimated by simulating production for 1,250 sow herds based either on Line I (I) females or Control Line (C) females. During generations 17-19, pure line I and C pigs, F1 crosses of I and C with Danbred<sup>®</sup> USA LLC Landrace (L), and 3-way crosses of LxI and LxC females mated with Danbred<sup>®</sup> USA LLC DH terminal boars (T) were compared for reproductive, growth, and carcass traits. Those data

were used to simulate enterprises based on either I or C females. All replacement females and replacement boars for I and C were produced within the herd. AI was used to produce F1 and 3-way cross litters. The number of I or C sows was set at 50, and the distribution of F1 and 3-way cross litters was determined by farrowing rates, litter sizes, imposed selection rates and sow culling policies. Gross revenue was estimated assuming pigs were sold on the Sioux-Preme Packing Co. carcass grid. The numbers marketed for each group within the I enterprise were 909 Line I, 564 LxI, and 22,944 T(LxI) pigs. The numbers marketed for each group within the C enterprise were 733 Line C, 524 LxC, and 18,909 T(LxC) pigs. Variable and fixed costs per pig marketed were \$3.21 and \$2.98 less, respectively, for the enterprise based on I. Net revenue per pig

marketed averaged \$116.91 for the I enterprise, and \$115.76 for the C enterprise. Differences in net revenue per pig marketed between groups within the enterprises were \$3.05 for pure line I and C, -\$2.50 between F1 LxI and LxC, and \$2.89 between T(LxI) and T(LxC). The rate of return on investment was 6% greater for the I enterprise. Net return per pig marketed averaged -\$18.49 for pure line I and C, \$1.74 for F1 LxI and LxC, and \$22.14 for 3-way cross T(LxI) and T(LxC) pigs. The effect to a breeding enterprise of 18 generations of selection for increased litter size was estimated to be \$7.33 net return per pig marketed, which is \$0.41 per pig marketed per generation.

**Key Words:** Selection, Costs, Revenue

## Extension

**45 Evaluation of particle length reduction during silage removal using a bunker facer.** D. Sutter<sup>1</sup> and R. D. Shaver<sup>2</sup>, <sup>1</sup>*Brown County Extension, UW Extension*, <sup>2</sup>*Department of Dairy Science, UW Madison, UW Extension*.

Bunker-facer systems are being used on dairy farms in Wisconsin for silage removal. The objective of this study was to determine the effect of these systems on silage particle length. Silage was sampled three ways for particle length analysis: 1) hand removal from face, 2) after bucket removal from face, and 3) after facer-unit removal from face. Both corn silage and alfalfa silage bunkers were sampled. Hand removal was done using a trowel. Bucket removal was by working the bucket up the face to dislodge 10-15 cm of silage. Facer units were attached to either skid steers or sky lifts. The facer units were started at the top of the bunker and were worked down the face to remove 10-15 cm of corn silage or 5-10 cm of alfalfa silage. Composite samples were collected from the pile at the foot of the bunker. Particle length measurements were done using the Penn State-Nasco shaker box. Samples were taken on one day each week for three weeks on each farm. Bunker-facer systems evaluated were Valmetal (VM; Valmetal Co.), Bunker Buster (BB; Gehl, Co.), and Bunker Claw (BC; D&D Equipment). On Farm A, silage removal with VM was compared to hand removal for alfalfa silage. On Farm B, silage removal with VM was compared to hand removal for corn silage. On Farm C, silage removal with VM, BB, and BC were compared to hand removal for alfalfa silage. On Farm D, silage removal with BB was compared to hand and bucket removal for alfalfa silage and corn silage. Data were pooled across farms and analyzed using Proc GLM of SAS; the model included farm, forage type, sample day, bunker-facer system, forage by bunker-facer system, and farm by bunker-facer system effects. Corn silage was finer than alfalfa silage ( $P < 0.001$ ) and silage particle length varied by farm ( $P < 0.01$  and  $P < 0.001$  for coarse and fine screens, respectively). Silage particle length was unaffected by day of sampling, indicating that silages and sampling and sieving techniques were consistent across the study. Silage particle length was unaffected by bunker-facing system. Under the conditions of this study, we found no evidence that the bunker-facing systems evaluated reduce silage particle length during removal of silage from the bunker.

**Key Words:** Silage, Particle Length

**46 Influence of a rumen-fluid drench at calving on milk production and incidence of health disorders in early lactation dairy cows.** I. Possin<sup>1</sup>, J. Keuning<sup>2</sup>, and R. D. Shaver<sup>3</sup>, <sup>1</sup>*Fond du Lac County Extension, UW Extension*, <sup>2</sup>*Kewaunee County Extension, UW Extension*, <sup>3</sup>*Department of Dairy Science, UW Madison, UW Extension*.

We hypothesized that administering a rumen-fluid drench around the time of calving may reduce the incidence of health disorders and enhance milk production. Both no drench and warm-water drench were used as controls for the rumen-fluid drench treatment. The experiment was conducted on two commercial dairies. Cows were blocked by parity and expected calving date and assigned randomly to treatments. For Farm A, there were 300 cows assigned to the trial. Milk yields at the first (1-30 DIM) and second (31-60 DIM) tests averaged 27.7 kg/cow/day and 37.1 kg/cow/day, respectively, and were unaffected by treatment ( $P > 0.10$ ). Post-calving rectal temperatures were normal and unaffected by treatment across ten days of recording rectal temperatures ( $P > 0.10$ ). Incidence of retained placenta was higher ( $P < 0.001$ ) for fever (33.6%) than non-fever (14.3%) cows. Metritis incidence was higher ( $P < 0.01$ ) for fever (22.4%) than non-fever (10.3%) cows. Mastitis incidence was

higher ( $P < 0.05$ ) for fever (26.4%) than non-fever (15.4%) cows. The only significant ( $P < 0.01$ ) treatment observation for Farm A was for mastitis being higher for drenched cows (28.0% and 21.1% for water and rumen-fluid drenches, respectively) than control cows (11.4%). For Farm B, there were 189 cows assigned to the trial. Days in milk, milk yield, and 3.5% FCM yield at the first DHI test averaged 15.6 days, 34.1 kg/cow/day, and 37.5 kg/cow/day, respectively, and were unaffected by treatment ( $P > 0.10$ ). Days in milk, milk yield, and 3.5% FCM yield at the second DHI test averaged 45.9 days, 42.0 kg/cow/day, and 40.5 kg/cow/day, respectively, and were unaffected by treatment ( $P > 0.10$ ). Post-calving rectal temperatures were normal and unaffected by treatment across five days of recording rectal temperatures ( $P > 0.10$ ). Metritis incidence was higher ( $P < 0.001$ ) for fever (39.2%) than non-fever (5.2%) cows. The only significant ( $P < 0.05$ ) treatment observation for Farm B was for cow deaths, which totaled four of 64 for the control group and zero of 62 and 63 for the warm-water and rumen-fluid drench groups, respectively. Under the conditions of this experiment, a rumen-fluid drench around the time of calving did not improve early lactation milk production or reduce the incidence of health disorders.

**Key Words:** Rumen Fluid, Dairy Cows, Health

**47 The effect of antibiotic residues in raw milk on yogurt manufacture.** P.N. Dias<sup>1</sup>, D.W. Kellogg<sup>1</sup>, K.F.S.T. Silva<sup>2</sup>, and S. Dureirattam<sup>3</sup>, <sup>1</sup>*University of Arkansas, Fayetteville*, <sup>2</sup>*University of Peradeniya, Sri Lanka*, <sup>3</sup>*Milk Industries of Lanka Co., Ltd., Sri Lanka*.

The experiment assessed inhibitory effects of antibiotics (penicillin, oxytetracycline, ampicillin, and cloxacillin) that are registered for dairy cattle management in Sri Lanka on yogurt culture that contained a ratio of 1:1 *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The raw milk samples that contained different levels of commonly used antibiotics were tested in three replicates. The minimum detectable concentration of penicillin in milk was 0.005 mg/kg by bromocresol dye reduction method and was 0.05 mg/kg by disc assay technique. The inhibitory levels of the other antibiotics tested were below their detectable limits using the bromocresol and disc assay methods. Penicillin was the most sensitive antibiotic on the yogurt starter culture. In the process of yogurt production under 44°C incubation temperature and 2 h of incubation, 0.01 mg/kg of penicillin totally inhibited ( $P < 0.05$ ) acid production by yogurt culture. The inhibitory concentrations of ampicillin, cloxacillin, and oxytetracycline were 0.05, 0.3, and 0.5 mg/kg, respectively. Above these concentrations there was no yogurt setting observed. Titratable acidity development was reduced ( $P < 0.05$ ) with increasing concentrations of all antibiotics tested in milk, and beyond the inhibitory concentrations there was only slight increase ( $P < 0.05$ ) in acidity with time. Antibiotics in milk also affected ( $P < 0.05$ ) the total bacterial count (mean = 120,000) and the ratio of cocci to rods in yogurt mixture. In conclusion, the presence of specific antibiotic residues in milk inhibited acid production by starter culture bacteria markedly and affected the yogurt making process, leading to longer manufacturing time and poor setting of curd.

**Key Words:** Antibiotic Residues, Milk, Yogurt

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**47 The effect of antibiotic residues in raw milk on yogurt manufacture.** P.N. Dias<sup>1</sup>, D.W. Kellogg<sup>1</sup>, K.F.S.T. Silva<sup>2</sup>, and S. Dureirantnam<sup>3</sup>, <sup>1</sup>*University of Arkansas, Fayetteville*, <sup>2</sup>*University of Peradeniya, Sri Lanka*, <sup>3</sup>*Milk Industries of Lanka Co., Ltd., Sri Lanka*.

The experiment assessed inhibitory effects of antibiotics (penicillin, oxytetracycline, ampicillin, and cloxacillin) that are registered for dairy cattle management in Sri Lanka on yogurt culture that contained a ratio of 1:1 *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The raw milk samples that contained different levels of commonly used antibiotics were tested in three replicates. The minimum detectable concentration of penicillin in milk was 0.005 mg/kg by bromocresol dye reduction method and was 0.05 mg/kg by disc assay technique. The inhibitory levels of the other antibiotics tested were below their detectable limits using the bromocresol and disc assay methods. Penicillin was the most sensitive antibiotic on the yogurt starter culture. In the process of yogurt production under 44°C incubation temperature and 2 h of incubation, 0.01 mg/kg of penicillin totally inhibited ( $P < 0.05$ ) acid production by yogurt culture. The inhibitory concentrations of ampicillin, cloxacillin, and oxytetracycline were 0.05, 0.3, and 0.5 mg/kg, respectively. Above these concentrations there was no yogurt setting observed. Titratable acidity development was reduced ( $P < 0.05$ ) with increasing concentrations of all antibiotics tested in milk, and beyond the inhibitory concentrations there was only slight increase ( $P < 0.05$ ) in acidity with time. Antibiotics in milk also affected ( $P < 0.05$ ) the total bacterial count (mean = 120,000) and the ratio of cocci to rods in yogurt mixture. In conclusion, the presence of specific antibiotic residues in milk inhibited acid production by starter culture bacteria markedly and affected the yogurt making process, leading to longer manufacturing time and poor setting of curd.

**Key Words:** Antibiotic Residues, Milk, Yogurt

**48 Comparison of Bermudagrass and Caucasian Bluestem in a Dairy Grazing System.** C.W. Davis<sup>1</sup>, S.A. Hamilton<sup>\*1</sup>, T.R. Rickard<sup>1</sup>, G.J. Bishop-Hurley<sup>1</sup>, B.J. Steevens<sup>1</sup>, and R.J. Crawford, Jr.<sup>1</sup>, <sup>1</sup>University of Missouri Outreach and Extension.

Cool-season grasses provide a major source of nutrients during the spring and late fall grazing season. However, these cultivars have significantly less growth and quality during the summer months. In an effort to fill this gap, producers have utilized various warm-season annuals and perennials. Bermudagrass and caucasian bluestem were established at the University of Missouri SW Center's seasonal grazing dairy in 1998 to evaluate their potential for milk production. Eighteen lactating dairy cows were randomly assigned to one of two treatments in April of 2000 and 2001, consisting of bermudagrass (n=9) or caucasian bluestem (n=9). Cows were paired between treatments on days in milk, body size, breed and milk production. Animals received the same grain mix and had equal levels of consumption. Grazing was initiated in May when both grasses were two to three inches tall to establish the rotation. Both species were grazed in a vegetative state, seldom exceeding eight inches in height. Animals were moved to a new paddock twice a day corresponding to milking time.

Cows grazing caucasian bluestem produced more milk, both overall and within breeds, compared to cows grazing bermudagrass.

	Holstein	Jersey	Crossbred	Mean
Bermudagrass	53.80 <sup>1,a</sup>	44.78 <sup>3,a</sup>	49.57 <sup>2,a</sup>	49.38 <sup>a</sup>
Caucasian bluestem	56.35 <sup>1,b</sup>	50.11 <sup>2,b</sup>	54.44 <sup>1,b</sup>	53.63 <sup>b</sup>
Mean	55.07 <sup>1</sup>	47.44 <sup>3</sup>	52.00 <sup>2</sup>	

<sup>1,2,3</sup> Means with the same superscript in a row are not different (P<0.05)

<sup>a,b</sup> Means with the same superscript in a column are not different (P<0.05)

**Key Words:** Dairy Grazing, Bermudagrass, Caucasian Bluestem

**49 Changing photoperiod improves persistency in high producing Holstein cows.** P. A. Porter\* and C. M. Luhman, *Land O'Lakes, Webster City, Iowa/USA.*

Previous research has consistently shown improved milk production when a lactating cow's photoperiod is changed from a natural photoperiod to an 18 hour light, 6 hour dark photoperiod with a light intensity greater than 15 foot candles (long-day lighting, LDL). Prior to installation of a new lighting system at the Land O' Lakes Research Farm, the lighting program varied from 5 to 20 foot candles, depending on a cow's proximity to light fixtures, for a period of 20 to 24 hours per day. One 96 tie-stall barn had new lighting installed (NEW) to meet the LDL guidelines. An adjacent 72 tie-stall barn was used as a control (OLD). Milk production was measured for individual cows for one week in each barn just prior to the NEW system becoming operational and then again for one week 45 days (45D) after initiation of NEW lighting. Days in milk at initiation averaged 113 for 64 NEW cows and 163 for 21 OLD cows. Milk production for either all cows or cows > 50 days in milk (DIM) in NEW was compared to expected milk. Expected milk was calculated using either a standard persistency (7% decline per 28 days, NORMAL) or the persistency observed in OLD (12.6% or 13.7% decline in 45 days for all cows or cows >50 DIM, respectively). Regardless of comparison, actual production of NEW 45 days after initiation of lighting was significantly higher than expected (Table 1). The range of estimated response was 2.4 to 3.4 kg/cow/day. Return over cost of the improvement, including an estimated increase in DM intake, utility costs and capital costs was estimated at 90 days; labor costs for installation were not included. Assuming a response to LDL for 9 months annually, the added profit for this farm was \$96 per cow per year.

	Initial	45 D	OLD	NORMAL	SEM	45 D v. OLD	45 D v. NORMAL
	- - -	kg/d	- - -	- - -		P=	P=
All cows	46.1 <sup>a</sup>	43.0 <sup>b</sup>	40.2 <sup>c</sup>	40.6 <sup>c</sup>	.92	.03	.07
Cows > 50 DIM	44.8 <sup>a</sup>	41.9 <sup>b</sup>	38.5 <sup>c</sup>	39.4 <sup>c</sup>	.88	.01	.05

<sup>a,b,c</sup> Means within row differ, P<0.10

**Key Words:** Lactating Cows, Photoperiod, Long Day Lighting

**50 Fatty acid profiles of milk and rumen digesta from cows fed fish oil, extruded soybeans or their blend.** A. A. Abu-Ghazaleh<sup>\*1</sup>, D. J. Schingoethe<sup>1</sup>, A. R. Hippen<sup>1</sup>, K. F. Kalscheur<sup>1</sup>, and L. A. Whitlock<sup>1</sup>, <sup>1</sup>South Dakota State University.

Two fisulated primiparous Holstein cows and two fisulated Brown Swiss cows averaging 102 DIM were used in a 4 x 4 Latin Square, with 3 wk periods to determine the effect of feeding fish oil, extruded soybeans, or their combination on milk and rumen digesta fatty acid profiles. Experimental diets consisted of: 1) control diet; 2) a diet with 2% (DM basis) added fat from menhaden fish oil; 3) a diet with 2% added fat from extruded soybeans; and 4) a diet with 1% added fat from fish oil and 1% fat from extruded soybeans. All diets consisted of 25% corn silage, 25% alfalfa hay, and 50% concentrate mix. Milk yield (28.6, 29.7, 29.2, and 28.1 kg/d for control, fish oil, extruded soybeans, and combination diets, respectively) was not affected (P = 0.74) by fat supplements compared with control. Milk fat percentages (3.49, 3.25, 3.47, and 3.48) and milk protein percentages (3.08, 2.96, 3.01, and 2.99) were not affected (P > 0.28) by fat supplements compared with control. Dry matter intake (23.0, 21.6, 22.7, and 21.6 kg/d) was reduced (P < 0.05) only when fish oil was fed. Milk fat conjugated linoleic acid (cis #9, t-11 CLA, 0.40, 0.88, 0.87, and 0.80 g/100g FA) and transvaccenic acid (TVA, 1.02, 2.34, 2.41, and 2.06 g/100g FA) were increased (P < 0.01) with all fat supplements compared with control. However, no differences in milk CLA and TVA were observed between fat supplements. As with milk fat, proportions of ruminal CLA (0.09, 0.26, 0.18, and 0.18 g/100g FA) and TVA (2.61, 4.56, 4.61, and 4.39 g/100g FA) were increased (P < 0.01) with fat supplements. The effect of fat supplements on ruminal TVA and CLA concentrations were also reflected in rumen soaps, free fatty acids, and neutral lipid. The higher TVA to CLA ratio in the rumen compared with milk indicated that fat supplements increased milk CLA concentration mainly by increasing ruminal production of TVA, which also implied the significant role that mammary delta-9 desaturase plays in milk CLA production.

**Key Words:** Conjugated Linoleic Acid, Transvaccenic Acid, Rumen Digesta

**51 A survey of replacement heifer mineral feeding practices on Wisconsin dairy operations.** D.L. Zygarricke\* and P.C. Hoffman, *University of Wisconsin-Madison.*

Thirty dairy operations were randomly selected throughout Wisconsin to evaluate mineral feeding practices to dairy replacement heifers. Each farm was visited with an on-sight evaluation conducted by the same technician. Three groups of replacement heifers (200, 300, and 450 kg) were identified on each farm. The amount of each feed fed to each heifer group was determined from detailed total mixed ration records (if available) or by weighing feed ingredients fed. All feeds fed to replacement heifer groups were sampled and immediately determined for DM content. In cases where heifers were pastured, pasture was sampled by taking random .3 m clippings. The DMI of pasture by heifers was estimated by difference to NRC, 2000 DMI intake levels. After drying, feeds were ground through a 1 mm screen and a weighed total diet composite was made for each heifer group on a DM basis and Ca, P, Mg, K, Na, S, Fe, Cu, Mn, and Zn were determined using inductive coupled plasma emission spectroscopy. The Cl content of heifer diets was determined using a chloridometer. In addition, individual forages fed to heifers were determined for mineral content. Levels of minerals fed to replacement heifers were compared to a static NRC, 2001 requirement. In general, dairy operations fed excessive levels of Ca, P, Cl, K, Fe, Mn, Cu, and Zn to dairy replacement heifers. In most cases, heifers were fed dietary mineral contents 100% in excess of NRC requirements. In contrast, Na and S were deficient in approximately 25% of all heifer diets. Forages were generally deficient in P, Na, S, Cu, and Zn in meeting NRC requirements. Data suggest little precision is used in formulating heifer diets for mineral content.

**Key Words:** Heifers, Minerals, Nutrition

**52 Differences in characteristics of the immune systems of neonatal, juvenile, and adult Holsteins.** K. R. Martin, S. T. Franklin\*, and R. J. Harmon, *University of Kentucky.*

The immune system of young calves differs markedly from that of adult cows. In neonatal blood, leukocytes are present in different proportions with altered functional capacity compared to leukocytes of adults. The

objective of this study was to investigate the maturation of the neonatal immune system by evaluating characteristics of leukocytes that contribute to differences in the immune systems of neonatal, juvenile, and adult cattle. Peripheral blood was collected from 6 calves aged 7 to 15 d, 6 juveniles aged 4.5 to 7 mo, and 6 adult cows aged 3 to 4 yr. Leukocytes were isolated for flow cytometric analysis, in vitro proliferation assays, determination of membrane packing, and membrane fatty acid assays. Two animals from each age group were sampled on one day. Flow cytometry indicated that adult cows had greater ( $P < 0.05$ ) percentages of CD2+ and CD4+ cells, with more of these cells expressing the IL2 receptor and the MHCII molecule, compared to calves. Calves had greater ( $P < 0.05$ ) percentages of gamma/delta T cells and more of the cells expressed the IL2 receptor compared to cows. Juveniles had greater ( $P < 0.05$ ) percentages of B cells and more of the B cells expressed the MHCII molecule compared to calves and cows. Juveniles also had the greatest ( $P < 0.05$ ) total expression of MHCII. Total expression of the IL2 receptor did not differ among groups. In general, proliferation in response to mitogens was greater ( $P < 0.05$ ) for leukocytes from calves and juveniles compared to adult cows. Differences in membrane packing among age groups were not detected ( $P > 0.05$ ) but the fatty acid composition of leukocytes varied ( $P < 0.05$ ) according to age. Leukocytes from calves had greater concentrations of C16:0, C16:1trans, C18:1 (oleic acid), C18:1 (vaccenic acid), and 24:1 compared to adult cows. Leukocytes from adult cows had greater ( $P < 0.05$ ) concentrations of C18:0, C18:2 (linoleic acid), C20:3, C22:0, and C24:0 compared to calves. Differences in the fatty acid composition of leukocytes are likely because of diet and may contribute to differences in responsiveness of leukocytes to mitogenic stimulation in vitro. Leukocyte phenotype also likely contributes to in vitro differences in proliferation. Further understanding of maturation of the immune system in cattle may lead to ways to decrease risk of disease.

**Key Words:** Immune System, Cattle, Calves

**53 Effects of moderately increasing milk replacer feeding rate on performance and health of Holstein bull calves.** J. Sowinski<sup>\*1</sup>, D. Kuehn<sup>2</sup>, S. Hayes<sup>2</sup>, and P. Hoffman<sup>3</sup>, <sup>1</sup>Animix, Juneau, WI, <sup>2</sup>Milk Products, Chilton, WI, <sup>3</sup>University of Wisconsin, Madison.

One hundred Holstein bull calves were purchased at 2 to 4 d of age and assigned to one of four 56 d dietary treatments. Treatments were arranged in a 2 x 2 factorial in a completely randomized design and consisted of feeding calves either a control (C) rate of milk replacer (MR), (.45 kg/d), or a moderately increased (I) level of MR (.57 kg/d). Two milk replacers containing 20 or 25% CP from all milk sources were fed at C and I rates to complete the 2x2 factorial arrangement. The MR was divided into two equal portions, diluted to a constant 1.9 L volume and fed 2x/d. Calves were housed in an environmentally controlled barn (22 degrees C) in individual elevated crates and fed treatment diets 2x/d for 35 d. On d 36 to 42, calves were fed 1x/d, .23 and .29 kg/d of C and I respectively to facilitate weaning. Calves were offered a textured starter ad libitum containing 20% CP from d 3 to 56 of the experiment. Calves were evaluated for weight gain, frame growth, feed intake, feed efficiency, scours incidence, and medical treatment cost. Feeding calves MR containing 20 or 25% CP had no effect on calf performance or health nor was it interactive with MR feeding rate. Moderately increasing MR feeding rate (I vs C) resulted in increased ( $P < 0.10$ ) wither height gains (9.0 vs 7.8 cm/56d) and decreased medical cost (2.44 vs 3.57 dollars per calf). Moderately increasing MR feeding rate did not decrease ( $P > 0.10$ ) starter intake or increase ( $P > 0.10$ ) scour scores. Data suggest that MR feeding rate can be modestly increased to meet changing energy demands without negative effects on calf performance and health and that special high CP MR formulations may not be necessary under such conditions.

**Key Words:** Calves, Milk Replacer, Growth

**54 NDSU BeefSim: A Decision Support System for Cow/Calf Production Management.** P. Dash<sup>\*</sup> and T. Socha, North Dakota State University.

NDSU BeefSim is a computerized decision support system (DSS), developed at North Dakota State University, for cow/calf production management decision-making. It is a cow/calf production model that simulates a group of female cows and their calves. All calves are simulated from birth until weaning time. In addition to simulating animal growth, this

model also simulates range forage production and is capable of determining range forage availability on a daily basis. In other words, it integrates animal growth/production with pasture growth/production and simulates their dynamic relationships. The model simulates individual animal growth and the time unit used for simulation is one day. The BeefSim model is capable of simulating both purebred and crossbred production systems. The model is parameterized by user input describing animal inventory, breeding system, feed resources and their allocation to different animal age groups within the herd, description of rangeland, operational cost information, cow/calf market price, and strategic management practices. It is capable of evaluating the soundness of producer decisions in terms of carrying capacity, expected investment potential, size and scope of operations, and the ability to repay the loans. The model provides an intuitive graphical user interface for easy data input by the user and also for display of simulated results. The simulated results from BeefSim have been compared with actual North Dakota production data and found to be reliable for decision-making.

**Key Words:** Cow/Calf, Range, Simulation

**55 Factors affecting purchase prices of centrally-tested, yearling bulls from 1997 to 2000.** T.T. Marston<sup>\*1</sup>, D.W. Moser<sup>1</sup>, J.F. Gleghorn<sup>2</sup>, and L.E. Wankel<sup>1</sup>, <sup>1</sup>Kansas State University, Manhattan, <sup>2</sup>Texas Tech University, Lubbock.

Spring-born bulls (n=678) were sold at public auction through the Kansas Bull Test program. Statistical analysis was used to determine the value of catalog information. The final model ( $R^2=.71$ ) included the following independent variables: breed (n=6); year (n=4); breeder within breed (n=109); birth date; birth weight, ADG, WDA, test index within breed; ultrasound REA and marbling score; and EPDs for birth weight, weaning weight and milk ( $P<.10$ ). Non-significant factors that were tested ( $P>.10$ ) and removed stepwise from the model were: off-test weight, adjusted 205-d weight, frame score, yearling weight EPD, horn status within breed, scrotal circumference, color within breed, and ultrasound back fat. Breed influenced the bull's purchase value ( $P<.02$ ). Average sale price differed ( $P<.01$ ) from year to year with no established trend over the four year period. Buyers paid more for bulls from specific breeders within breed ( $P<.01$ ), suggesting that breeder reputation and individual selling techniques can affect sale price. Earlier born bulls garnished  $\$3.33 \pm 1.00$  more per day of age ( $P<.01$ ). Individual animal performance was rewarded ( $P<.01$ ) as indicated by premiums paid for lower birthweight (-1 kg =  $\$32.60 \pm 6.35$ ), greater ADG (1 kg =  $\$797.23 \pm 250.90$ ) and greater WDA (1 kg =  $\$1,814.98 \pm 371.23$ ). Test indexes were calculated for bulls by averaging the ADG and WDA within breed ratios and were listed in the sale catalog. Buyers used the index to value bulls ( $P<.09$ ) but weighted the index value differently depending on the breed purchased. Ultrasound marbling scores were positively related to price with each unit increase in marbling score worth  $\$50.42 \pm 17.14$  ( $P<.08$ ). Differences in REA were worth  $\$7.81 \pm 2.66 / \text{cm}^2$  ( $P<.01$ ). Depending on breed, birth weight ( $P<.01$ ), weaning weight ( $P<.01$ ) and milk ( $P<.06$ ) EPDs were used by buyer to differentiate bull's value. This analysis indicates that yearling bull buyers utilize several different factors to determine the value of their purchases.

**Key Words:** Beef cattle, Performance, Ultrasound

**56 Practical aspects of beef carcass traceability in commercial beef processing plants using an electronic identification system.** J. R. Davis<sup>\*</sup> and M. E. Dikeman, Kansas State University, Manhattan, KS.

Increased producer ownership through slaughter has revealed a need for accurate animal and carcass traceability from carcass merit, payment, and meat safety standpoints. Protocols in many commercial beef processing plants are inadequate to trace carcasses back to individual live animals. Electronic identification (EID) system use in plants holds great potential as a tool for traceability, if used as part of a comprehensive carcass tracking system. For most kill floors, it is naive to assume that individual ear tags can be read and always matched exactly with carcass identification numbers because potential exists for the carcass sequence (CS) to be altered from the kill sequence by one or more head per lot. Cattle may be temporarily railed out of the CS if they require additional trimming, fall from the rail, or are retained. The hot carcass scale (HCS) operator must keep track of carcasses railed out of and returned to the CS, a system that is not infallible. Also, lots may be accidentally mixed in holding pens. Cattle may be re-associated with their lot only if each

animal in that lot bears a common tag. For 1,821 cattle slaughtered in 8 lots and bearing button-type EID tags, 63 (3.46%) had non-functional tags, 12 (0.66%) had no tag, and 37 extra head were introduced accidentally into one lot by holding pen workers. Of the 1,821 carcasses, 52 (2.86%) were railed out, 5 (0.27%) were retained, and 2 (0.11%) were condemned. Although EID readers are used in some large plants, they are part of a system that does not remove human error. We propose an EID reader with two opposing panels plus a mechanical 'trip' counter (to correct for missing or non-functional tags), through which exsanguinated cattle would pass. The EID reader would be integrated with a printer to produce an individual bar-code tag to be applied to each carcass prior to the hide puller, and scanned at the HCS. An integrated computer system could then correspond EID numbers with plant identification numbers and grade data, and assure traceability.

**Key Words:** Electronic Identification, Traceability, Cattle

**57 MinCheck: A computer tool for understanding and utilizing results from feed and water mineral analysis.** C.A. Bandyk<sup>1</sup>, D.A. Blasi<sup>\*2</sup>, and M.H. Hogan<sup>3</sup>, <sup>1</sup>*Trails End Farm Consulting & Software, Mineral Point, WI*, <sup>2</sup>*Kansas State University, Manhattan, KS*, <sup>3</sup>*SDK Laboratories, Hutchinson, KS*.

Livestock producers are repeatedly advised of the importance of mineral nutrition, and the inherent value of routinely testing feed and water supplies for key mineral levels. However, the values returned from a typical laboratory analysis are not, by themselves, of practical use to most cattlemen. A need was identified for a tool to aid in understanding and utilizing this information. Computer software was developed, using Visual Baler<sup>TM</sup>, to assist the user in interpreting the results of a forage and (or) water mineral analysis in relation to a particular class of beef cattle. Using an estimate of forage intake, dietary supplies of Ca, P, K, Mg, Na, S, Al, Co, Cu, Fe, M, Mo, Zn, and Se are calculated and compared to requirements as given in the 1996 NRC Nutrient Requirements of Beef Cattle. Nutrient profiles and expected intake of 1 or 2 mineral supplements may be entered, and checked for adequacy in the given feeding situation. Values for water pH, chloride, nitrate-N, Ca, Mg, Na, sulfate, total dissolved solids (TDS), and Fe may be entered and checked against specific thresholds. Appropriate warning messages are generated for any measure that warrants concern. A complimentary copy may be downloaded at: [http://www.oznet.ksu.edu/dp\\_ansi/software/software.htm](http://www.oznet.ksu.edu/dp_ansi/software/software.htm).

**Key Words:** Mineral Analysis, Beef Cattle, Software

**58 Performance of calves on two commercially available calf starter feeds.** M.L. O'Brien\*, K.J. Touchette, and J.A. Coalson, *Merrick's Inc. Union Center, WI USA*.

The consumption of calf starter by young calves at an early age is important for the development of a functioning rumen and to achieve optimal growth. By the fourth week of life, calves should be consuming more nutrients from calf starter than from milk replacer, which increases the importance of feeding a nutritious, highly palatable starter. Two commercially available calf starters were evaluated at Merrick's Inc. research farm in Union Center, WI. Holstein bull calves (n=120), less than 7 days of age were purchased from an area sale barn. Using a randomized complete block design, with initial weight as the blocking factor, calves were assigned to either calf starter A (18% protein, 5% fat) or B (18% protein, 3% fat) and to one of three milk replacer diets (no significant interactions between calf starter diet and milk replacer diet existed). Calves were housed in individual hutches with water available free choice from d 0. A high quality, commercial calf starter was available free choice beginning at d 7. Feed intake, incidence of scours and antibiotic treatments were recorded daily. Calves were weighed weekly. Calves were weaned at a minimum of 42 d with weaning dependent on the calf eating a minimum of 454 g of calf starter for 3 consecutive d. Calves fed starter A had greater average weekly weights beginning at week 4 and lasting the rest of the trial (P<0.05), greater total weight gains (39.7 kg, 30.1 kg for A and B, respectively; P<0.05), greater ADG (P<0.05) and higher feed intakes from week 3 through the end of the trial (P<0.05). Weaning age for calves fed starter A was, on average, 2 days earlier than calves on starter B (P<0.05). These results indicate that the importance of feeding a high quality, nutritious calf starter to young dairy calves should not be overlooked on the dairy farm.

**Key Words:** Calves, Starter, Growth

**59 Effect of folic acid in calf milk replacer on performance and scouring of calves.** T. E. Johnson\*, H. B. Perry, D. C. Hammell, M. A. Fowler, and B. L. Miller, *Land O'Lakes, Webster City, Iowa/USA*.

Folic acid was evaluated in an all milk protein calf milk replacer to determine its effect on performance and scour data of Holstein bull and heifer calves. A total of 66 calves with an initial weight of 47.50 kg were assigned alternating by order of birth (equal number of each sex per treatment) to milk replacers devoid or containing folic acid (15 mg folic acid per feeding). Milk replacers were formulated to contain 22% protein and 20% fat and were medicated with neo-terramycin. Calves were individually housed outside in hutches and fed 2 times daily at 700 and 1615 hours. Common starter diets (commercial, 18% texturized, 90 g lasalocid/909 kg) were fed. Weight gains were determined at 21 and 42 days, daily milk replacer consumption, daily dry feed consumption, feed efficiency, daily scour scores (1-4 scale; 1=normal; 2=loose; 3=water separation; 4=3 with severe dehydration), duration of scours and electrolyte/medication costs were calculated weekly and for the 6 week period. Total 6 week weight gain, milk replacer DM consumption, dry feed consumption, feed efficiency, scour score, duration of scours and electrolyte/medication costs of calves fed the conventional calf milk replacer without or with folic acid were 19.55, 20.14 kg; 23.80, 23.64 kg; 23.90, 25.49 kg; 2.57, 2.51; 1.03, 1.05; 1.33, 2.02 days; and \$6.65, \$7.82, respectively. These data indicate that using 15 mg per feeding in all milk protein milk replacer had little merit when used with a common starter diet.

**Key Words:** Folic Acid, Calves, Milk Replacer

**60 Liquid egg as an alternative protein source in calf milk replacers.** K.J. Touchette\*, M.L. O'Brien, and J.A. Coalson, *Merrick's Inc. Union Center, WI USA*.

The use of alternative proteins in milk replacer have been evaluated extensively for their ability to decrease the cost of milk replacers and because alternative proteins are more readily available than milk proteins. The objective of these studies was to evaluate the performance of calves on milk replacer containing liquid egg as an alternative protein. On arrival, calves were assigned to a diet of all milk protein milk replacer (MILK) or a diet containing 5% of the diet from liquid egg (MILK+EGG). For both experiments, milk replacers were formulated to contain protein and fat levels at 20% of DM and were fed 454 g/d reconstituted to 12% DM. Production of the MILK+EGG diet utilized breaker eggs that were pasteurized during production of the milk replacer. Holstein bull calves (n=44 for Exp. 1 and n=38 for Exp. 2), were purchased from an area sale barn. Experiment 1 utilized a complete randomized design. Experiment 2 utilized a randomized complete block design with initial weight as the blocking factor. Calves were housed in individual hutches with water available free choice from d 0. A high quality, commercial calf starter was available free choice beginning at d 7. Feed intake, incidence of scours and antibiotic treatments were recorded daily. Calves were weighed weekly. Calves were weaned at a minimum of 42 d with weaning dependent on the calf eating a minimum of 454 g of calf starter for 3 consecutive d. For Exp. 1 calves fed MILK+EGG had significantly greater average weekly weight gains and ADG (P<0.05) than calves fed MILK. No differences in ADFI were observed between groups. For Exp. 2, there were no significant differences in weekly weight gains, ADG, ADFI or feed efficiency between calves fed MILK or MILK+EGG. These results indicate that egg can be used as an effective alternative protein source to replace a portion of milk protein in a commercial calf milk replacer.

**Key Words:** Calves, Egg, Alternative Proteins

**61 Comparison of Neomycin/Oxytetracycline and Neomix 325 SP in All Milk Calf Milk Replacer.** H. B. Perry\*, T. E. Johnson<sup>1</sup>, D. C. Hammell<sup>1</sup>, M. A. Fowler<sup>1</sup>, and B. L. Miller<sup>1</sup>, <sup>1</sup>*Land O'Lakes, Webster City, Iowa/USA*, *Pharmacia & Upjohn, Kalamazoo, Michigan/USA*.

Neomycin/Oxytetracycline and Neomix 325 SP were evaluated in an all milk protein calf milk replacer to determine its effect on performance and scour data of Holstein bull calves. A total of 40 calves with an initial weight of 48.7 kg were randomly assigned according to body weight and blood gamma globulin concentration to: 1) Neomycin/Oxytetracycline 400:200 g/T for entire trial; 2) Neomix 325 SP 2080 g/T for initial 14



days and non-medicated for the duration of the trial. Milk replacers were formulated to contain 22% protein and 20% fat. Calves were individually housed in crates and fed 2 times daily at 700 and 1615 hours. No calf starter was offered throughout the trial, therefore milk replacer was fed according to a modified feeding schedule. Weekly weight gains, daily milk replacer consumption, feed efficiency, daily scour scores (1-4 scale; 1=normal; 2=loose; 3=water separation; 4=3 with severe dehydration), duration of scours and respiratory scores (1 respiratory day for each day therapeutic antibiotic given for respiratory infection) were calculated weekly and for the 4 week period. Total 4 week weight gain, milk replacer DM consumption, feed efficiency, scour score, duration of scours and respiratory scores of calves fed the conventional calf milk replacer containing Neomycin/Oxytetracycline or Neomix 325 SP were 11.08 and 11.45 kg; 21.72 and 21.57 kg; 2.03 and 1.93; 1.19 and 1.19; 4.35 and 4.67 days; and 2.05 and 3.22, respectively. Data from this trial indicates no significant differences ( $P>0.05$ ) between Neomycin/Oxytetracycline or Neomix 325 SP in all milk protein milk replacer.

**Key Words:** Neomycin/Oxytetracycline, Neomix 325 SP, Calf Milk Replacer

## 62 Evaluation of Sea-Questra-Min Zinc fed in an All Milk Calf Milk Replacer. D. C. Hammell\*, T. E. Johnson, H. B. Perry, M. A. Fowler, and B. L. Miller, *Land O'Lakes, Webster City, Iowa/USA.*

Sea-Questra-Min (SQM) Zinc was evaluated in an all milk protein calf milk replacer to determine its effect on performance and scour data of Holstein bull calves. A total of 36 sale barn calves were randomized and assigned to either the control diet or the diet containing SQM Zinc (25 mg/Zn/hd, daily). Milk replacer was formulated to contain 22% protein and 20% fat and was medicated with neo-terramycin. Calves were housed inside on raised crates and fed two times daily at 630 and 1500 hours. No calf starter was offered throughout the duration of the trial. Weight gains, daily milk replacer consumption, feed efficiency, daily scour scores (1-4 scale; 1=normal; 2=loose; 3=water separation; 4=3 with severe dehydration), duration of scours, electrolyte/medication costs and respiratory scores were calculated weekly and for the 4 week period. Total 4 week weight gain, milk replacer DM consumption, feed efficiency, scour score, duration of scours, electrolyte/medication costs and respiratory scores of calves fed the control diet or diet with SQM Zinc were 12.78, 11.31 kg ( $P=0.0090$ ); 22.79, 22.35 kg; 1.81, 2.00 ( $P=0.0333$ ); 1.19, 1.36 ( $P=0.0193$ ); 5.33, 9.00 days ( $P=0.0460$ ); \$4.67, \$10.68 ( $P=0.0013$ ) and 0.67, 2.53 ( $P=0.0139$ ), respectively. These data indicate that using Sea-Questra-Min Zinc in all milk protein milk replacer had no beneficial effects.

**Key Words:** Sea-Questra-Min Zinc, Calves, Milk Replacer

## 63 The importance of the level of fat in an accelerated feeding program. M. L. O'Brien\*, K. J. Touchette, and J.A. Coalson, *Merrick's Inc. Union Center, WI USA.*

The objective of this study was to determine the effect of feeding two levels of fat in an accelerated feeding program. Holstein bull calves ( $n=120$ ), less than 7 d of age were purchased from an area sale barn. Using a randomized completed block design, calves were assigned by weight to milk replacer diets: 1) a control diet of 20% of DM as protein and fat (CONTROL) 2) 25% and 20% of DM as protein and fat respectively (HP) or 3) 25% and 15% of DM as protein and fat, respectively (HPLF). Diet 1 was fed at 454 g/d (12% DM) while diets 2 and 3 were fed at 675 g/d (18% DM). Calves were housed in individual hutches with water available free choice from d 0. A high quality, commercial calf starter was available free choice beginning at d 7. Feed intake, incidence of scours and antibiotic treatments were recorded daily. Calves were weighed weekly. Calves were weaned at a minimum of 42 d with weaning dependent on the calf eating a minimum of 454 g of calf starter for 3 consecutive d. Calves fed HP and HPLF were significantly ( $P<0.05$ ) heavier than calves fed the CONTROL for the entire trial beginning on d 7. On d 14, calves on the CONTROL diet had gained only 0.83 kg, while calves receiving HP and HPLF diets gained 3.55 and 4.02 kg, respectively. ADG were greater for calves fed HPLF (708 g/d) and HP (654 g/d) than for calves fed CONTROL (522 g/d,  $P<0.05$ ). Numerically, calves fed HPLF had the heaviest body weights (83.25 kg) compared to HP (80.45 kg) and CONTROL (72.74 kg). Feed efficiencies were significantly improved ( $P<0.05$ ) for calves fed HPLF (0.55 kg/kg)

and HP (0.54 kg/kg) than calves fed CONTROL (0.50 kg/kg). Numerically, total starter intakes were greater for calves fed HPLF (47.5 kg) than for calves fed HP (42.1 kg) and CONTROL (41.9 kg). All calves averaged less than 1 d scouring and less than 3 d treated with antibiotics with no differences between treatments. Feeding lower levels of fat in an accelerated feeding program improves growth and efficiency of young dairy calves.

**Key Words:** Calves, Fat, Growth

## 64 Effects of feeding supplemental fats in calf milk replacers during periods of cold stress on intake, growth and health of dairy calves. K.J. Touchette\*, M.L. O'Brien, and J. A. Coalson, *Merrick's Inc. Union Center, WI USA.*

An experiment was conducted to determine the effects of feeding supplemental fat in calf milk replacers during periods of cold stress. Holstein bull calves ( $n=60$ ), less than 7d of age were purchased from an area sale barn. Using a randomized complete block design, calves were assigned by weight to diets of 1) all milk protein milk replacer (MR; 20%CP and 20% fat from DM); 2) MR plus a fat supplement (MR+, 7% protein, 60% fat from DM or 3) high fat milk replacer (HFMR; 17% CP and 28% fat from DM). Solids for each diet were: MR fed at 454 g/d (2088 kcal); MR+ fed at 454 g/d of MR and 56.7g per feeding of the fat supplement when the outside temperature at feeding was below 0°C (2840 kcal); and HFMR fed at 568.7 g/d (2840 kcal). Calves were fed 1.9 L of milk replacer twice daily. During the trial, 75% of feedings occurred at temperatures below 0°C. Calves were housed in individual hutches with water available free choice from d 0. A high quality, commercial calf starter was available free choice beginning at d 7. Feed intake, incidence of scours and antibiotic treatments were recorded daily. Calves were weighed weekly. Calves were weaned at a minimum of 42 d with weaning dependent on the calf eating a minimum of 454 g of calf starter for 3 consecutive d. Calves fed higher amounts of dietary fat (MR+, HFMR) had consistently greater weekly weight gains throughout the study. On day 14 calves fed MR were on average 1.35 kg lighter than calves fed MR+ and HFMR. This difference increased to 2.25 kg on d 21. Total weight gains were also greater for MR+ and HFMR diets (47.4, 47.5, 45.7 kg respectively for MR+, HFMR and MR). Additionally, average daily gains were greater for MR+ and HFMR (849, 849, 817 g/d for MR+, HFMR, and MR respectively). Overall, health of the calves was excellent with only 3.3% mortality and no significant differences in number of days scoured or number of medical treatments. These results indicate that increasing the level of dietary fat fed to calves during periods of cold stress may help maintain or improve calf growth.

**Key Words:** Calves, Fat, Cold Stress

## 65 Effects of increased energy and protein intake on growth rates, skeletal growth and body composition of Holstein heifer calves less than four months of age. E.G. Brown\*, M.J. VandeHaar, K.M. Daniels, and M.S. Weber Nielsen, *Michigan State University, East Lansing, MI.*

The objective of this study was to determine how increasing energy and protein intakes would affect growth rates, skeletal growth and body composition in Holstein heifer calves less than 4 months of age. At 2 weeks of age, purchased calves ( $n=42$ ) were randomly assigned to one of four treatment groups (LL, LH, HH, HL). Groups were fed to achieve either a low (400 g/d) or high (1,200 g/d) rate of gain from 2 to 8 weeks of age, and low or high rate of gain from 8 to 14 weeks of age. Group L was fed a standard milk replacer (20% CP, 20% fat) and calf starter (18% CP, 3% fat), and group H was fed a high protein milk replacer (28.5% CP, 15% fat) and calf starter (22% CP, 3% fat). Calves were gradually weaned from milk replacer by 7 weeks of age. At 14 weeks of age the calves were slaughtered. Final body weight (BW) and total average daily gain (ADG) for LL, LH, HH, and HL groups were 79, 105, 122 and 87 kg and 417, 597, 883 and 571 g. Ending withers heights were 88, 92, 94, and 90 cm for LL, LH, HH, and HL groups, respectively, with a greater weight to height ratio for groups LH and HH ( $P < 0.001$ ). There was no difference in gain to feed ratio among the groups ( $P > 0.40$ ). No difference was observed in carcass protein or ash percentage, but groups LH and HH had 3% less water ( $P < 0.005$ ) and 3% more fat ( $P < 0.0001$ ) than groups LL and HL. Compared to LL, the lean to fat ratios of HH and HL were similar, but LH was lower. Compared to LL, the total feed costs per kg of gain were similar for LH and HH, but were higher for HL. Increasing energy and protein intake from 2

to 14 weeks of age increased BW, withers height, and carcass protein mass, and slightly increased carcass fat concentration without altering feed efficiency or feed cost per kg of gain.

**Key Words:** Body Composition, Calves, Intake

**66 Transport of colostral macromolecules into the Cerebrospinal fluid via plasma in newborn calves.** M.J.R. Talukder, T. Takeuchi, and E. Harada, *Yamaguchi University*.

The objective of this study was to investigate the transfer of bovine colostral macromolecules especially the lactoferrin (Lf), transferrin (Tf), immunoglobulin G (IgG) and epidermal growth factor (EGF) from the gastrointestinal tract to the cerebrospinal fluid (CSF) via systemic circulation in newborn calves. Cannulae were placed into the jugular vein and cisterna magna to collect blood and CSF, respectively at different time points. The colostrum, plasma and CSF were analyzed by ELISA, SDS-PAGE, two-dimensional PAGE, and Western blotting. The concentration of total protein, Lf, Tf, IgG in plasma were 47.1 mg, 204.0 ng, 100.9 ug and 15.4 ug/ml at pre-administration state, which were steeply increased to the peak value of 64.2 mg, 2412.5 ng, 819.9 ug and 4607.5 ug/ml after 8 h of colostrum administration, respectively. In the CSF of pre-administration state, total protein, Lf, Tf, and IgG level were 0.44 mg, 10.3 ng, 0.31 ug and 0.11 ug/ml, which were dramatically changed by colostral feeding and reached to the highest value of 1.98 mg, 172.7 ng, 70.6 ug and 72.1 ug/ml after 10 h, respectively. Immunologically, six EGF-positive protein bands were found in colostrum and higher density in 3 bands were observed in plasma and CSF after colostrums feeding. This study revealed that the colostral macromolecules were not only absorbed into the systemic circulation, but also some of them including Lf, Tf, IgG and EGF-like proteins were transported into the CSF in a time dependent manner through blood-CSF barrier of the newborn calves.

**Key Words:** Lactoferrin, Transferrin, Cerebrospinal Fluid

**67 Effects on growth and carcass traits of feeding PAYLEAN<sup>®</sup> at 18 g per ton to F1 and 3-way cross pigs of the NE Index Line.** D. Petry<sup>\*1</sup>, R. Johnson<sup>1</sup>, R. Fischer<sup>1</sup>, and P. Miller<sup>1</sup>, <sup>1</sup>*University of Nebraska, Lincoln*.

The objective was to determine the effects of feeding 18 g PAYLEAN<sup>®</sup> per ton during the last 28 d of the feeding period on growth and carcass traits of pigs with 25 or 50% NE Index Line genes. Line I was selected 19 generations for increased litter size and does not differ from the control line for growth or carcass traits. A total of 306 barrows and gilts from 56 litters, including 153 F1 pigs of Line I females crossed with Danbred<sup>®</sup> USA LLC Landrace boars (L) and 153 3-way cross pigs of LxI females crossed with Danbred<sup>®</sup> USA LLC DH terminal boars (T) were used. Pigs were fed a diet (3,320 kcal ME/kg) with 0.95% lysine from 65 to 86 d of age, 0.88% lysine from 86 d of age to 28 d before slaughter, and 0.95% lysine the last 28 d. Pigs were penned individually (n=66) or in pens of 10 of the same sex and genetic group (n=240). Both genetic groups and sexes responded similarly to PAYLEAN<sup>®</sup>. Feeding PAYLEAN<sup>®</sup> for 28 d increased growth rate (0.99 vs. 0.82 kg/d), reduced feed intake (2.94 vs. 3.09 kg/d) and improved gain/feed ratio (0.33 vs. 0.26) (P<0.01). Pigs fed PAYLEAN<sup>®</sup> had heavier carcasses (84.08 vs. 80.36 kg), greater dressing percentage (75.2 vs. 74.3%), and more lean as estimated by TOBEC (53.6 vs. 49.9%) (P<0.01). Treatment differences in pH and Minolta L\* color score were small (P>0.07). Three-way cross pigs grew faster (0.92 vs. 0.89 kg/d) than F1 pigs (P<0.05). Differences in daily feed intake (2.64 vs. 2.61 kg/d) and gain/feed (0.35 vs. 0.34) were not significant. Three-way cross pigs had less backfat (1.57 vs. 1.63 cm), larger longissimus muscle area (41.42 vs. 39.35 cm<sup>2</sup>), greater percentage lean (52.4 vs. 51 %), and greater Minolta L\* color score (50.4 vs. 48.6) than F1 pigs (P<0.05). Differences in pH (5.72 vs. 5.79) were not significant. Performance and value of 3-way cross pigs were greater than for F1 pigs and feeding PAYLEAN<sup>®</sup> at the rate of 18 g per ton significantly increased performance and carcass value of both groups.

**Key Words:** Ractopamine HCl, Growth, Litter Size

**68 Use of a hands-on workshop to teach swine reproductive management to farrowing barn workers.** J. A. Sterle<sup>\*1</sup> and L. J. Johnston<sup>2</sup>, <sup>1</sup>*Texas A&M University, College Station*, <sup>2</sup>*University of Minnesota West Central Research and Outreach Center, Morris*.

Farrowing barn workers are vital to the success of a swine operation. Workers often conduct management practices with little understanding of the justification for these practices. A hands-on workshop was developed to provide workers with an understanding of biological principles behind common management practices. Small groups of students rotated through three stations during the two-hour workshops. At station 1, dissection of a pregnant reproductive tract included explanation of timing of reproductive events, inspection of anatomy and discussion of management strategies such as movement of sows, feeding and nutritional effects, estrous detection, and parturition. Models of a sow's pelvis were used at station 2 to enhance the ability to diagnose/treat dystocia problems. Students were given preserved fetal pigs in various malpresentations and practiced correctly extracting the piglets. Models allowed visualization of the reproductive tract so students became more at ease solving dystocia problems. At station 3, farrowing crates were prepared correctly and incorrectly to receive sows. Participants identified common mistakes, including improper use of supplemental heat, improper processing equipment, and poorly adjusted crates. Feeding the sow, vaccinations, and piglet processing were discussed and experiences shared among students. Students appeared interested and stayed the entire allotted time. At one presentation, students completed a formal evaluation. Responding students (40%) scored the workshop a 4 on a 1(not beneficial) to 5 (extremely beneficial) scale. Comments by the students stated that they appreciated the opportunity to "see" inside a sow, contributing to the understanding of many aspects of reproductive management and benefited from the exchanges between students. While this approach involved more time and labor and was more expensive than traditional lectures, the favorable response from students indicated it was more effective for this audience.

**Key Words:** Farrowing Management, Training, Hands-On

**69 Effects of canine teeth clipping on pig performance.** M.D. Hoge<sup>\*</sup>, R.O. Bates, D.B. Edwards, and B.E. Straw<sup>1</sup>, *Michigan State University, East Lansing, MI USA*.

The effect of clipping canine teeth on pre- and post-weaning performance was measured on 3,184 pigs from 318 sows on a Michigan commercial farm. Within five weekly farrowing groups, females were randomly allocated to either have their litter#s canine teeth clipped or remain intact. Michigan State University personnel processed litters within 24 h after farrowing. Processing consisted of ear notching, tagging, tail docking, castration, iron supplementation, clipping canine teeth of designated litters, and recording individual weights. Daily mortalities and within treatment cross fostering were recorded. At three d of age, each pig was assigned a face score (0-5) for scrapes and abrasions. A zero indicated no marks and five indicated severe scrapes and abrasions. Four d prior to weaning, pigs were weighed and face scores again assigned. Time from birth to weighing prior to weaning was 13 ± 2.1 d. At weaning, pigs were moved into off-site nurseries. Prior to movement to finishers, pigs (n=2,363) were weighed to determine nursery weight gain. Estimated variances within treatment were not significantly different from each other for either nursing weight gain or nursery average daily gain. Nursing weight gain for pigs with either clipped or intact canine teeth, (2.72 vs 2.79kg, respectively) and near weaning weight (4.40 vs 4.49kg, respectively) were similar. The parity by treatment interaction was significant for nursing mortality. A trend (P≤0.10) for lower mortality for pigs with intact canine teeth was detected within parity 1. Pigs with clipped teeth had poorer survival (P≤0.05) with older than parity 5 dams. Treatment differences were significant for face scores at Day 3 of lactation and near weaning. Pigs with intact canine teeth were 2.5 and 1.5 times more likely to have higher face scores than pigs with clipped teeth at Day 3 and near weaning, respectively. Nursing and nursery pig performance was similar for pigs with or without canine teeth, however pigs with intact canine teeth did incur more facial abrasions.

**Key Words:** Pig, Canine Teeth, Growth

**70 Wet corn gluten feed and CP for steam flaked corn-based finishing diets.** H. C. Block<sup>\*1</sup>, C. N. Macken<sup>1</sup>, T. J. Klopfenstein<sup>1</sup>, R. J. Cooper<sup>2</sup>, and R. A. Stock<sup>2</sup>, <sup>1</sup>University of Nebraska - Lincoln, <sup>2</sup>Cargill.

A 166-d feeding trial was conducted to evaluate combinations of wet corn gluten feed (WCGF) and CP in steam flaked corn-based finishing diets. The trial used 360 steer calves ( $288 \pm 11$  kg) in an incomplete  $4 \times 3$  CRD feeding trial. Treatments were WCGF (0, 20, 30, and 40% of DM) and CP (13.0, 13.7, and 14.4% of DM) via supplemental urea. The 0% WCGF treatment included only 13.7% CP, and 40% WCGF included only 13.7 and 14.4% CP. Steers were housed in 36 open lot pens, allowing 4 replicates per treatment combination. Final CP contents were 13.9% CP for 0% WCGF, 13.4, 14.1, and 14.8% CP for 20% WCGF, 13.5, 14.2, and 14.9% CP for 30% WCGF, and 14.5 and 15.0% CP for 40% WCGF. Hot carcass weight, ADG, and feed efficiency (ADG:DMI) responded to WCGF in a quadratic fashion ( $P \leq 0.05$ ). The 20, 30, and 40% WCGF treatments increased predicted ADG by 107, 106, and 103%, respectively, relative to 0% WCGF. Feed efficiency was 102, 101, and 98% for 20, 30, and 40% WCGF, respectively, relative to 0% WCGF. Dry matter intake increased linearly ( $P \leq 0.05$ ) in response to increased WCGF. Hot carcass weight, ADG, and feed efficiency increased linearly ( $P \leq 0.05$ ) in response to increased CP. Non-linear analysis for degradable intake protein (DIP) over the combined 20 and 30% WCGF treatments indicated DIP requirements of 8.6% of DM for ADG, and 8.4% of DM for feed efficiency, corresponding to 13.8 and 13.6% CP for 20% WCGF and 14.0 and 13.8% CP for 30% WCGF, respectively. Carcass fat thickness, marbling, ribeye area, and yield grade were unaffected by WCGF or CP. These results indicate that the amount of WCGF to include in steam flaked corn-based finishing diets to maximize ADG and feed efficiency was 20% to 30% of DM, with a linear response to increased CP supplementation. The requirement for DIP in these diets was approximately 8.5% of DM.

**Key Words:** Wet Corn Gluten Feed, CP, Steam Flaked Corn

**71 The effect of freezing on Warner-Bratzler shear force values in beef longissimus steaks across several post-mortem aging periods.** B. C. Shanks<sup>\*</sup>, D. M. Wulf, and R. J. Maddock, *South Dakota State University, Brookings, SD.*

The objective of this study was to compare two Warner-Bratzler shear force (WBSF) protocols: a) **Fresh protocol** = WBSF measurement of steaks cooked on the exact day the aging period ended vs b) **Frozen protocol** = WBSF measurement on steaks that were aged, frozen (-16°C) for approximately two mo, thawed for 24 h, and then cooked. Right and left side strip loins from 20 crossbred heifers and steers were sliced into 11 steaks each (22 steaks per animal), individually vacuum-packaged, and randomly assigned to either fresh or frozen protocol and one of 11 aging periods (1, 2, 3, 4, 5, 6, 7, 10, 14, 21, or 35 d). Following the appropriate aging/storage protocol, steaks were broiled on Farberware Open Hearth electrical broilers to an internal temperature of 71°C and up to six 1.27-cm-diameter cores parallel to muscle fiber orientation were sheared using a Warner-Bratzler shear machine. Frozen protocol resulted in lower ( $P < 0.05$ ) WBSF values than fresh protocol for beef longissimus steaks that were aged for 1, 2, 3, 4, 6, 7, 10, 14, or 35 d post-mortem. The interaction between protocol and postmortem aging for WBSF was significant ( $P < 0.05$ ) and indicated that the effect of freezing on WBSF values decreased as aging period increased. Correlations revealed that frozen protocol WBSF values were not highly indicative of fresh protocol WBSF values at the same period of postmortem aging, but rather, suggested that frozen protocol WBSF values at shorter aging times were useful in estimating WBSF values from fresh protocols at longer aging times. Cooking loss was higher ( $P < 0.05$ ) for frozen vs fresh protocol steaks at all aging periods except for 14, 21, or 35 d. These findings suggest that if research constraints warrant the freezing of samples, d-7 WBSF should be used because it is the best measurement of fresh aged beef (14 to 21 d) tenderness. In trials where several postmortem aging periods or very short aging periods are of interest, it is recommended that WBSF be assessed using the fresh protocol.

**Key Words:** Beef, Freezing, Warner-Bratzler Shear Force

**72 Effect of previous liveweight gain on visceral organ mass and oxygen consumption in cattle during high-grain feeding.** M. J. Hersom<sup>\*</sup>, C. R. Krehbiel, and G. W. Horn, *Oklahoma State University, Stillwater, OK.*

Forty-eight fall-weaned crossbred steers ( $231 \pm 25$  kg) were used in a completely random design to determine the effect of previous liveweight gain on visceral organ mass and oxygen consumption. During the 143-d growing phase, treatments were high (HGW; 1.28 kg/d) or low (LGW; .48 kg/d) daily BW gain on wheat pasture or dormant native range (NR; .21 kg/d). Before finishing, four steers per treatment were harvested, organ mass recorded, and oxygen consumption by liver, ruminal epithelium, and duodenal tissues was measured. All remaining steers were individually fed a high-grain diet for 86, 111, and 162 d for HGW, LGW and NR, respectively, to a common 1.27 cm of backfat. At final harvest, six steers per treatment were selected for harvest to obtain organ mass and measure oxygen consumption. Initial empty body weight (EBW) was greater ( $P < .01$ ) for HGW steers than LGW, which were greater than NR steers ( $382 > 303 > 245$  kg EBW, respectively). Liver, rumen, and small intestine (g/kg EBW) were greater ( $P < .01$ ) in NR than HGW or LGW. Similarly, total gastrointestinal tract (GIT) and total splanchnic tissues (TST) were greater ( $P < .01$ ) in NR than HGW and LGW ( $80.3 > 51.8$  and  $57.9$ , and  $108.3 > 90.0$  and  $90.2$  g/kg EBW, respectively). Initial oxygen consumption by the liver was greater ( $P = .02$ ) in HGW and LGW than NR ( $35.2$  and  $33.8 > 16.2$  mL·min<sup>-1</sup>·tissue<sup>-1</sup>), whereas duodenal initial oxygen consumption was greater ( $P = .02$ ) in LGW than HGW or NR ( $12.06 > 5.77$  or  $4.97$  mL·min<sup>-1</sup>·tissue<sup>-1</sup>). Initial ruminal epithelium oxygen consumption in HGW was greater ( $P = .03$ ) than NR. During finishing, NR steers increased EBW at a greater rate ( $P < .01$ ) than either HGW or LGW ( $1.83 > 1.38$  and  $1.28$  kg·d<sup>-1</sup>). In contrast, change in GIT and TST were less ( $P < .01$ ) in NR than HGW and LGW steers ( $-.12 < .13$  and  $.08$ , and  $.01 < .23$  and  $.21$  g/kg EBW·d<sup>-1</sup>, respectively). Native range steers had a greater rate of EBW gain and a lower rate of GIT and TST gain than HGW or LGW steers. Coupled with lower oxygen consumption by splanchnic tissues, this could relate to an increased efficiency of energy use for maintenance during feedlot finishing in NR steers.

**Key Words:** Splanchnic Tissue, Oxygen Consumption, Cattle

**73 Influence of carnitine and/or chromium on blood parameters of gestating sows.** J.C. Woodworth<sup>\*</sup>, M.D. Tokach, J.L. Nelssen, R.D. Goodband, S.S. Dritz, J.E. Minton, and K.Q. Owen<sup>1</sup>, *Kansas State University, Manhattan, <sup>1</sup>Lonza, Inc., Fair Lawn, NJ.*

Gestating sows ( $n=44$ ; parity=2.0; BW=208 kg) were used to determine the effects of dietary L-carnitine (Carn) and/or chromium picolinate (Cr) on daily blood parameter profiles. Diets were formulated as a  $2 \times 2$  factorial with Carn (0 or 50 ppm) and Cr (0 or 200 ppb) and were fed from breeding, through gestation, lactation, and 30 d into the next gestation at which time blood collection occurred. Sows were fed one meal per day during gestation (2.1 kg) and ad libitum during lactation. Sows were fitted with indwelling venous catheters and blood (serum) was collected at feeding, once every 15 min for the first 3 h after feeding, and at 6, 9, 15, 20, and 24 h after feeding. Chromium elicited its greatest effect immediately after feeding (0-3 h) by decreasing ( $P < 0.05$ ) insulin and c-peptide, whereas Carn decreased ( $P < 0.05$ ) NEFA and urea N (SUN) in the fasted state (6-24 h post-feeding). Sows fed both Carn and Cr exhibited intermediate responses. Post-feeding glucose peak was lower ( $P < 0.05$ ) for diets with Carn and/or Cr versus the control and mean glucose concentration was lower ( $P < 0.01$ ) for sows fed diets with Cr. Mean insulin and c-peptide concentration was lowest ( $P < 0.01$ ) for sows fed the diet with Cr and highest for sows fed the control, with sows fed diets with Carn or Carn and Cr having intermediate responses (Carn  $\times$  Cr,  $P < 0.01$ ). Mean NEFA was lower ( $P < 0.01$ ) for sows fed diets with Carn and higher ( $P < 0.03$ ) for sows fed the diet with Cr compared to control sows. Sows fed the diet with only Carn had the lowest SUN, but no differences were observed between the other three diets (Carn  $\times$  Cr,  $P < 0.01$ ). No differences were observed for IGF-1 or glucagon ( $P > 0.10$ ); however, sows fed Carn had numerically higher ( $P = 0.11$ ) IGF-1. In summary, the changes in metabolites and metabolic hormones indicate that both Carn and Cr influence energy metabolism of gestating sows; however, their effects on blood parameters are different. Thus, adding both Carn and Cr may have a synergistic effect on reproductive performance.

**Key Words:** Sow, Carnitine, Chromium

## Graduate Student Competitive Research Papers M.S. Divisions

**74 Pre- and postweaning performance of pigs injected with dexamethasone at birth.** A.M. Gaines<sup>\*1</sup>, J.A. Carroll<sup>2</sup>, G.L. Allee<sup>1</sup>, G.F. Yi<sup>1</sup>, J.D. Spencer<sup>1</sup>, J.W. Frank<sup>1</sup>, and D.C. Kendall<sup>1</sup>, <sup>1</sup>University of Missouri-Columbia, <sup>2</sup>Animal Physiology Research Unit, ARS-USDA, Columbia, Missouri.

A trial was conducted to determine pre- and postweaning performance of pigs injected with dexamethasone (Dex) either 1 or 24 hr after birth. In Exp1, at an 1800 head commercial sow unit, 225 pigs (TR4 x C22) were assigned according to birth weight and sex to three treatments. Treatments (Trt) included either saline (Cont), Dex1 (2-mg/kg BW i.m. injection of Dex within 1 hr of birth) or Dex24 (2-mg/kg BW i.m. injection of Dex within 24 hr after birth). Birth weights ( $1.56 \pm 0.36$  kg) did not differ among Trt ( $P > 0.96$ ) or between sexes ( $P > 0.70$ ). For body weight (BW) at weaning (15d), there was a Trt x Sex interaction ( $P < 0.02$ ) with Dex males 12% heavier than Cont males (4.8 vs. 4.3 kg, respectively) and Dex females lighter than Cont females (4.5 vs. 4.8 kg, respectively). In Exp2, 186 pigs from Exp1 were transported to a nursery facility. There were 10 pens/Trt/Sex (60 pens). Pigs were fed fortified corn-soybean meal diets in a three-phase feeding program. At the end of Exp2 (49d period) there was a Trt x Sex interaction ( $P < 0.01$ ) for BW with Dex barrows 8% heavier than the Cont barrows (30.0 vs. 27.8 kg, respectively) and no difference in gilts. No differences in feed efficiency (G:F) were observed during the nursery period. In Exp3, pigs from the nursery were moved to a finishing facility where there were 4 pens/Trt/Sex (24 pens). All pigs were fed fortified corn-soybean meal diets in a four-phase feeding program with sexes fed separately. Real-time ultrasound was used to measure 10th rib backfat depth (BF) and loin-eye area (LEA). At the end of Exp3 (83d period) there was a Trt x Sex interaction ( $P < 0.04$ ) for final BW with Dex barrows being 4.9 kg heavier than Cont barrows (119.6 vs. 114.7 kg, respectively) and no difference in gilts. No treatment differences were observed for BF, LEA or G:F ( $P > 0.10$ ). These studies demonstrate that Dex given within 24 hours of birth significantly improves both pre- and postweaning performance of barrows with no beneficial effects on gilts.

**Key Words:** Dexamethasone, Pigs, Birth

**75 Effect of formulating grow-finish swine diets using standardized ileal amino acid digestibility values on nutrient excretion and odor emissions from slurry.** J. S. Knott<sup>\*</sup> and G. C. Shurson, University of Minnesota, St. Paul, MN.

Effect of diet formulation on nutrient excretion, gas and odor emissions from slurry was evaluated in a 16-wk study. Barrows (n=16) received either a corn-soybean meal diet containing 0.075% synthetic lysine (CTL) and formulated on a total amino acid basis, or a diet low in N and S formulated on a standard ileal digestible amino acid basis using synthetic amino acids (SID). Feces and urine were collected and mixed daily from four metabolism crates per treatment, separated into four equal sub-samples, and added to one of four DPSM corresponding to the assigned crate. Eight pairs of pigs were assigned to crates and alternated in and out of crates every two wks during the experiment. Nutrient balance (GE and N) was determined using a 3d total collection period four times throughout the experiment. Hydrogen sulfide (H<sub>2</sub>S) and ammonia

(NH<sub>3</sub>) concentrations were measured weekly. Air samples were collected at 5 wk intervals and analyzed for odor detection threshold (ODU), intensity (OI), and hedonic tone (OHT). Feeding SID diets had no effect on GE and N retention or excretion. During wk 4, H<sub>2</sub>S emissions were low ( $< 1.8$  ppm), but were greater ( $P < .10$ ) from manure produced by pigs fed the SID diets. During wks 7, 11 ( $P < .15$ ) and 16 ( $P < .05$ ), there was a reduction in H<sub>2</sub>S emissions from manure of pigs fed SID diets, and differences in H<sub>2</sub>S emissions between treatments were greatest during wk 16 (3.41 vs 8.06 ppm for CTL and SID, respectively). Manure from pigs fed SID diets had lower NH<sub>3</sub> emissions for wks 11 ( $P < .15$ ) and 14 ( $P < .05$ ). No differences between treatments were observed for ODU, OI, and OHT. Slurry samples from each DPSM were collected at the end of wk 16 and analyzed for DM, N, and S. Slurry from pigs fed the SID diets had higher ( $P < .05$ ) DM, N, and S concentrations compared to slurry from pigs fed CTL diets. These results suggest that formulating grow-finish diets using SID may be effective in reducing NH<sub>3</sub> and H<sub>2</sub>S emissions in slurry, but has no effect on ODU, OI, and OHT, or GE and N balance.

**Key Words:** Amino Acids, Odor, Swine

**76 Influence of linoleic acid isomers on body fat in mice.** K. M. Hargrave<sup>\*</sup> and J. L. Miner, University of Nebraska - Lincoln.

Conjugated linoleic acid (CLA) causes a loss of body fat when fed to mice, rats, and pigs. Elongation and desaturation of CLA in animal tissues produces conjugated isomers of arachidonic acid. We hypothesize that this metabolism is required for the CLA-mediated reduction in body fat and that this metabolism is enhanced during linoleate deficiency. Our objective was to determine whether mice fed a diet deficient in essential fatty acids (EFAD) are more sensitive than mice fed a control diet to the anti-obesity effect of CLA. Eighty, newly weaned male mice (3 wk of age, 14 g BW) were blocked by weight and allotted to a 2 x 2 factorial arrangement of dietary treatments: Control = 7% soy oil diet for 8 wk; Control + CLA = Control diet for 6 wk then 6.5% soy oil + 0.5% CLA diet for 2 wk; EFAD = 7% coconut oil diet for 8 wk; EFAD + CLA = EFAD diet for 6 wk then 6.5% coconut oil + 0.5% CLA diet for 2 wk. Feed intake and BW were measured weekly. After 8 wk the mice were killed, and liver, and retroperitoneal (RP), and epididymal (Epi) fat pads were removed and weighed. Body fat percentage (BF%) was determined by ether extraction. Addition of CLA to the Control diet reduced ( $P < 0.05$ ) BW by 8% and feed intake by 11%, and reduced ( $P < 0.01$ ) fat pad weights (0.37 vs 0.19 g and 0.61 vs 0.45 g for RP and Epi pads, respectively) and BF% (21.08 vs 15.37%). There was no Control vs EFAD diet main effect. However, there was a pronounced CLA x EFAD interaction ( $P < 0.001$ ). Body fat depletion by CLA was 40% greater in mice fed the EFAD diet than in mice fed the Control diet. We conclude that mice fed essential fatty acid deficient diets are especially sensitive to the anti-obesity effect of CLA. This supports our hypothesis that the anti-obesity effect of CLA involves elongation and desaturation of CLA.

**Key Words:** Conjugated Linoleic Acid, Body Fat, Essential Fatty Acids

## Growth, Development, Muscle Biology, And Meat Science

**77 Effect of feather meal on live animal performance and carcass quality and composition of growing-finishing swine.** C. B. Boger<sup>\*</sup>, J. K. Apple, C. V. Maxwell, W. J. Roberts, and K. G. Friesen, University of Arkansas.

Crossbred pigs (n=120; BW=24.5±0.1 kg) were used to assess the effects of dietary valine (VAL), from hydrolyzed feather meal (FM), on performance and carcass traits of growing-finishing swine. Pigs were blocked by BW, allotted to 24 pens (5 pigs/pen), and pens were assigned randomly to 1 of 4 treatments: 1) positive control (PC) corn-soybean meal (SBM) starter, grower, and finisher diets; 2) negative control (NC) corn-SBM-wheat middlings starter, grower, and finisher diets that met minimum requirements for VAL; 3) NC-diets supplemented with 3% FM; and 4) NC-diets supplemented with 6% FM. Within FM-diets, FM was substituted for SBM on an equal lysine basis at the expense of

wheat middlings. All diets were formulated to be isocaloric, and fed in 4 phases with diet transition occurring when mean block weight was 36, 68, and 91 kg, respectively. When the lightest block averaged 107 kg, all pigs were harvested, and Fat-O-Meater fat and longissimus muscle (LM) depths and hot carcass weight were recorded. After a 24-h chilling period, Lean content of hams from left side of carcasses was determined using TOBEC. Loins were captured and used to measure instrumental color and drip loss. Neither PC, NC, nor FM-supplemented diets affected ( $P>0.10$ ) ADG, ADFI, or G:F, and dietary treatments had no effect ( $P>0.10$ ) on fat and LM depths, or lean composition of the carcass and ham. There was a linear trend ( $P<0.07$ ) for L\* values to increase as FM increased in the wheat middlings-based diets; however, the LM of pigs fed NC-diets was redder ( $P<0.01$ ) than the LM of pigs fed PC or FM-supplemented diets, and the LM from pigs fed FM-supplemented

## Graduate Student Competitive Research Papers M.S. Divisions

**74 Pre- and postweaning performance of pigs injected with dexamethasone at birth.** A.M. Gaines<sup>\*1</sup>, J.A. Carroll<sup>2</sup>, G.L. Allee<sup>1</sup>, G.F. Yi<sup>1</sup>, J.D. Spencer<sup>1</sup>, J.W. Frank<sup>1</sup>, and D.C. Kendall<sup>1</sup>, <sup>1</sup>University of Missouri-Columbia, <sup>2</sup>Animal Physiology Research Unit, ARS-USDA, Columbia, Missouri.

A trial was conducted to determine pre- and postweaning performance of pigs injected with dexamethasone (Dex) either 1 or 24 hr after birth. In Exp1, at an 1800 head commercial sow unit, 225 pigs (TR4 x C22) were assigned according to birth weight and sex to three treatments. Treatments (Trt) included either saline (Cont), Dex1 (2-mg/kg BW i.m. injection of Dex within 1 hr of birth) or Dex24 (2-mg/kg BW i.m. injection of Dex within 24 hr after birth). Birth weights ( $1.56 \pm 0.36$  kg) did not differ among Trt ( $P > 0.96$ ) or between sexes ( $P > 0.70$ ). For body weight (BW) at weaning (15d), there was a Trt x Sex interaction ( $P < 0.02$ ) with Dex males 12% heavier than Cont males (4.8 vs. 4.3 kg, respectively) and Dex females lighter than Cont females (4.5 vs. 4.8 kg, respectively). In Exp2, 186 pigs from Exp1 were transported to a nursery facility. There were 10 pens/Trt/Sex (60 pens). Pigs were fed fortified corn-soybean meal diets in a three-phase feeding program. At the end of Exp2 (49d period) there was a Trt x Sex interaction ( $P < 0.01$ ) for BW with Dex barrows 8% heavier than the Cont barrows (30.0 vs. 27.8 kg, respectively) and no difference in gilts. No differences in feed efficiency (G:F) were observed during the nursery period. In Exp3, pigs from the nursery were moved to a finishing facility where there were 4 pens/Trt/Sex (24 pens). All pigs were fed fortified corn-soybean meal diets in a four-phase feeding program with sexes fed separately. Real-time ultrasound was used to measure 10th rib backfat depth (BF) and loin-eye area (LEA). At the end of Exp3 (83d period) there was a Trt x Sex interaction ( $P < 0.04$ ) for final BW with Dex barrows being 4.9 kg heavier than Cont barrows (119.6 vs. 114.7 kg, respectively) and no difference in gilts. No treatment differences were observed for BF, LEA or G:F ( $P > 0.10$ ). These studies demonstrate that Dex given within 24 hours of birth significantly improves both pre- and postweaning performance of barrows with no beneficial effects on gilts.

**Key Words:** Dexamethasone, Pigs, Birth

**75 Effect of formulating grow-finish swine diets using standardized ileal amino acid digestibility values on nutrient excretion and odor emissions from slurry.** J. S. Knott<sup>\*</sup> and G. C. Shurson, University of Minnesota, St. Paul, MN.

Effect of diet formulation on nutrient excretion, gas and odor emissions from slurry was evaluated in a 16-wk study. Barrows (n=16) received either a corn-soybean meal diet containing 0.075% synthetic lysine (CTL) and formulated on a total amino acid basis, or a diet low in N and S formulated on a standard ileal digestible amino acid basis using synthetic amino acids (SID). Feces and urine were collected and mixed daily from four metabolism crates per treatment, separated into four equal sub-samples, and added to one of four DPSM corresponding to the assigned crate. Eight pairs of pigs were assigned to crates and alternated in and out of crates every two wks during the experiment. Nutrient balance (GE and N) was determined using a 3d total collection period four times throughout the experiment. Hydrogen sulfide (H<sub>2</sub>S) and ammonia

(NH<sub>3</sub>) concentrations were measured weekly. Air samples were collected at 5 wk intervals and analyzed for odor detection threshold (ODU), intensity (OI), and hedonic tone (OHT). Feeding SID diets had no effect on GE and N retention or excretion. During wk 4, H<sub>2</sub>S emissions were low (< 1.8 ppm), but were greater ( $P < .10$ ) from manure produced by pigs fed the SID diets. During wks 7, 11 ( $P < .15$ ) and 16 ( $P < .05$ ), there was a reduction in H<sub>2</sub>S emissions from manure of pigs fed SID diets, and differences in H<sub>2</sub>S emissions between treatments were greatest during wk 16 (3.41 vs 8.06 ppm for CTL and SID, respectively). Manure from pigs fed SID diets had lower NH<sub>3</sub> emissions for wks 11 ( $P < .15$ ) and 14 ( $P < .05$ ). No differences between treatments were observed for ODU, OI, and OHT. Slurry samples from each DPSM were collected at the end of wk 16 and analyzed for DM, N, and S. Slurry from pigs fed the SID diets had higher ( $P < .05$ ) DM, N, and S concentrations compared to slurry from pigs fed CTL diets. These results suggest that formulating grow-finish diets using SID may be effective in reducing NH<sub>3</sub> and H<sub>2</sub>S emissions in slurry, but has no effect on ODU, OI, and OHT, or GE and N balance.

**Key Words:** Amino Acids, Odor, Swine

**76 Influence of linoleic acid isomers on body fat in mice.** K. M. Hargrave<sup>\*</sup> and J. L. Miner, University of Nebraska - Lincoln.

Conjugated linoleic acid (CLA) causes a loss of body fat when fed to mice, rats, and pigs. Elongation and desaturation of CLA in animal tissues produces conjugated isomers of arachidonic acid. We hypothesize that this metabolism is required for the CLA-mediated reduction in body fat and that this metabolism is enhanced during linoleate deficiency. Our objective was to determine whether mice fed a diet deficient in essential fatty acids (EFAD) are more sensitive than mice fed a control diet to the anti-obesity effect of CLA. Eighty, newly weaned male mice (3 wk of age, 14 g BW) were blocked by weight and allotted to a 2 x 2 factorial arrangement of dietary treatments: Control = 7% soy oil diet for 8 wk; Control + CLA = Control diet for 6 wk then 6.5% soy oil + 0.5% CLA diet for 2 wk; EFAD = 7% coconut oil diet for 8 wk; EFAD + CLA = EFAD diet for 6 wk then 6.5% coconut oil + 0.5% CLA diet for 2 wk. Feed intake and BW were measured weekly. After 8 wk the mice were killed, and liver, and retroperitoneal (RP), and epididymal (Epi) fat pads were removed and weighed. Body fat percentage (BF%) was determined by ether extraction. Addition of CLA to the Control diet reduced ( $P < 0.05$ ) BW by 8% and feed intake by 11%, and reduced ( $P < 0.01$ ) fat pad weights (0.37 vs 0.19 g and 0.61 vs 0.45 g for RP and Epi pads, respectively) and BF% (21.08 vs 15.37%). There was no Control vs EFAD diet main effect. However, there was a pronounced CLA x EFAD interaction ( $P < 0.001$ ). Body fat depletion by CLA was 40% greater in mice fed the EFAD diet than in mice fed the Control diet. We conclude that mice fed essential fatty acid deficient diets are especially sensitive to the anti-obesity effect of CLA. This supports our hypothesis that the anti-obesity effect of CLA involves elongation and desaturation of CLA.

**Key Words:** Conjugated Linoleic Acid, Body Fat, Essential Fatty Acids

## Growth, Development, Muscle Biology, And Meat Science

**77 Effect of feather meal on live animal performance and carcass quality and composition of growing-finishing swine.** C. B. Boger<sup>\*</sup>, J. K. Apple, C. V. Maxwell, W. J. Roberts, and K. G. Friesen, University of Arkansas.

Crossbred pigs (n=120; BW=24.5±0.1 kg) were used to assess the effects of dietary valine (VAL), from hydrolyzed feather meal (FM), on performance and carcass traits of growing-finishing swine. Pigs were blocked by BW, allotted to 24 pens (5 pigs/pen), and pens were assigned randomly to 1 of 4 treatments: 1) positive control (PC) corn-soybean meal (SBM) starter, grower, and finisher diets; 2) negative control (NC) corn-SBM-wheat middlings starter, grower, and finisher diets that met minimum requirements for VAL; 3) NC-diets supplemented with 3% FM; and 4) NC-diets supplemented with 6% FM. Within FM-diets, FM was substituted for SBM on an equal lysine basis at the expense of

wheat middlings. All diets were formulated to be isocaloric, and fed in 4 phases with diet transition occurring when mean block weight was 36, 68, and 91 kg, respectively. When the lightest block averaged 107 kg, all pigs were harvested, and Fat-O-Meater fat and longissimus muscle (LM) depths and hot carcass weight were recorded. After a 24-h chilling period, Lean content of hams from left side of carcasses was determined using TOBEC. Loins were captured and used to measure instrumental color and drip loss. Neither PC, NC, nor FM-supplemented diets affected ( $P>0.10$ ) ADG, ADFI, or G:F, and dietary treatments had no effect ( $P>0.10$ ) on fat and LM depths, or lean composition of the carcass and ham. There was a linear trend ( $P<0.07$ ) for L\* values to increase as FM increased in the wheat middlings-based diets; however, the LM of pigs fed NC-diets was redder ( $P<0.01$ ) than the LM of pigs fed PC or FM-supplemented diets, and the LM from pigs fed FM-supplemented

diets had higher ( $P < 0.01$ )  $a^*$  values than pigs fed PC-diets. LM chops from pigs fed NC- and FM-supplemented diets were more ( $P < 0.02$ ) yellow than LM chops of pigs fed PC-diets. Results suggest that altering dietary VAL content by supplementing diets with FM had little to no effect on pig performance or carcass composition, but may have some beneficial effects on pork color.

**Key Words:** Feather meal, Swine, Valine

**78 Effects of dietary manganese on quality characteristics of pork longissimus muscle (LM) chops during retail display.** W. J. Roberts<sup>\*1</sup>, J. K. Apple<sup>1</sup>, C. B. Boger<sup>1</sup>, C. V. Maxwell<sup>1</sup>, K. G. Friesen<sup>1</sup>, and T. M. Fakler<sup>2</sup>, <sup>1</sup>University of Arkansas, <sup>2</sup>Zinpro Corporation.

The objective of this experiment was to test the effects of dietary manganese (Mn) source and inclusion level on quality traits and lipid oxidation of LM chops during retail display. Pigs ( $n=100$ ) were blocked by BW, assigned to pens (4 pigs/pen) within blocks, and pens (5 pens/block) were allotted randomly to either control corn-soybean meal starter, grower, and finisher diets (C), or Mn-supplemented diets arranged in a  $2 \times 2$  factorial design with 2 inclusion levels (350 or 700 ppm) and 2 Mn-sources (Avala<sup>®</sup>-Mn [Mn-amino acid complex] or  $MnSO_4$ ). When the lightest block averaged 107 kg, all pigs were harvested, and pork loins were captured from left sides after a 24-h chilling period. Loins were processed into 2.5-cm thick LM chops, placed on foam trays, and overwrapped with polyvinyl chloride film for retail display ( $4^\circ C$ ; deluxe warm white light; 1630 lx). On d 0, 2, 4, and 6 of display, subjective (American and Japanese color scores) and instrumental color were measured, then chops were removed from packaging material and LM samples were assayed for TBARS. No ( $P > 0.10$ ) display day  $\times$  diet interactions were noted for color, drip loss, or TBARS. Dietary Mn had no effect ( $P > 0.10$ ) on drip loss during display, but chops from pigs fed 350 ppm Mn from Avala-Mn received higher Japanese ( $P < 0.05$ ) and American ( $P < 0.12$ ) color scores than pigs fed C, 700 ppm Mn from Avala-Mn, or 350 and 700 ppm Mn from  $MnSO_4$ . The LM from pigs fed 350 ppm Mn from Avala-Mn tended to be darker ( $P < 0.12$ ) and less yellow ( $P < 0.05$ ) than the LM from pigs fed C or 700 ppm Mn from Avala-Mn. The LM from pigs fed 350 ppm Mn from  $MnSO_4$  tended to have lower ( $P < 0.10$ ) TBARS values than the LM from pigs consuming C or diets containing 700 ppm Mn from Avala-Mn. Results indicate that supplementing diets with 350 ppm Mn may enhance pork quality during retail display; however, inclusion of 700 ppm Mn, regardless of source, had no beneficial effects on pork color or lipid oxidation.

**Key Words:** Manganese, Pork Quality, Retail Display

**79 The effect of feeding Ractopamine (Paylean<sup>TM</sup>) on loin quality and sensory characteristics in three genetic lines of swine.** G.M. Stoller<sup>\*1</sup>, H.N. Zerby<sup>1</sup>, S.J. Moeller<sup>1</sup>, T.J. Baas<sup>2</sup>, C.D. Johnson<sup>2</sup>, and L.E. Watkins<sup>3</sup>, <sup>1</sup>The Ohio State University, Columbus, OH, <sup>2</sup>Iowa State University, Ames, IA, <sup>3</sup>Elanco Animal Health, Greenfield, IN.

This experiment was designed to evaluate the effects of ractopamine hydrochloride (RAC) on meat quality and sensory attributes of three genetic lines of swine. Berkshire ( $n = 76$ ), Duroc ( $n = 81$ ), and high-lean (HL) commercial crossbred ( $n = 75$ ) barrows and gilts were allocated to be fed standard commercial diets supplemented with two different levels of RAC (0 or 10 ppm). The trial was conducted using a randomized complete block design, with animals blocked according to litter, gender, and starting weight. Pigs were started on the experimental diet at approximately 85.1 kg and remained on test for a period of 28 d. Pigs were harvested at a commercial abattoir and muscle quality measurements taken at 24 and 48 h post-mortem. Quality traits measured were visual firmness (24 h), visual wetness (24 h), ultimate pH (24 h and 48 h), visual marbling (48 h), visual color (48 h), Minolta color scores (24 h and 48 h) and water-holding capacity (WHC). Sensory attributes of the loin were assessed by a three-person trained sensory panel 7 to 10 d after harvest. Sensory traits included: juiciness, tenderness and chewiness (sustained tenderness). Instrument measurements of tenderness (Instron), percentage cooking loss and chemically separated loin lipid content (intramuscular fat, IMF) were obtained. The RAC treatment had no significant effect on muscle quality assessments, sensory attributes or instrument measures of palatability. Differences were observed between genetic lines for most quality and sensory traits, with Berkshire pigs generally being superior. Loins from barrows were firmer

( $P < .05$ ), had a higher pH at 48 h pH ( $P < .05$ ), had less drip loss ( $P < .05$ ) and had improved sensory tenderness scores ( $P < .05$ ) when compared with loins from gilts. For IMF, genetic line by treatment and genetic line by gender interactions were discovered. Berkshire pigs fed RAC had a lower ( $P < .05$ ) percentage of IMF than control pigs. The purebred barrows (Berkshire and Duroc) had higher ( $P < .001$  and  $P < .05$ , respectively) IMF than their respective purebred gilts, with no gender difference in IMF in the HL line. The results from this experiment support the findings that feeding RAC does not affect muscle quality and palatability characteristics.

**Key Words:** Swine, Ractopamine, Muscle Quality

**80 Fresh pork loin quality associated with domestic or export storage.** D. M. McNamara<sup>\*1</sup>, T. W. Holthaus<sup>2</sup>, R. C. Johnson<sup>3</sup>, C. R. Calkins<sup>2</sup>, and E. P. Berg<sup>1</sup>, <sup>1</sup>University of Missouri, <sup>2</sup>University of Nebraska, <sup>3</sup>Triumph Pork Group, LLC.

Data were collected on 479 fresh, boneless, center-cut pork loins (NAMP 412B) to evaluate quality characteristics after storage for 21 or 42 days at  $2^\circ C$ . Loins were collected from commercial hybrid pigs harvested in eight groups in August and September. Loins were fabricated under normal commercial conditions at 24h postmortem, weighed, vacuum packaged, boxed and delivered via refrigerated truck (550 km) to the University of Missouri. Storage durations were chosen to simulate domestic (21d) or export (42d) storage intervals. After storage, purge loss, color scores (instrumental and subjective), subjective marbling scores, pH, Warner-Bratzler shear force measurements, and percentage cooking loss were obtained for each loin. CIE  $L^*$ ,  $a^*$ , and  $b^*$  values were recorded on the cut lean surface (15 min bloom) of the blade, center, and sirloin sections using a Color-TEC PCM color meter (Color-Tec Associates, Inc. Clinton NJ). Center-loin pH (approx. 10th rib) was recorded using the SFK Technology, Inc. (Cedar Rapids, IA) PH Star probe. Chops were cut from each loin (approx. 10th rib), weighed, and cooked to  $70^\circ C$  on a MagiKitchen belt grill (Blodgett Co., Quakertown, PA), allowed to cool (approx. 5 h), then reweighed to determine percentage cooking loss. Six, 1.3-cm cores were removed parallel to the muscle fibers and measured for Warner-Bratzler shear force. Compared to domestic storage (21d), loins stored for simulated export (42 d) had lower  $L^*$  values recorded on the blade (53.19 vs. 51.44), center (49.56 vs. 48.44), and sirloin (48.38 vs. 47.57) surfaces ( $P < 0.05$ ). Subjective NPPC color scores were contrary to  $L^*$  values with domestic color scores higher ( $P < 0.001$ ) than export on the blade (3.2 vs. 2.8) and sirloin end (3.4 vs. 3.0). Export purge loss (3.26%) was higher ( $P < 0.05$ ) than domestic (2.97%) and shear force was higher for export (3.25 kg) compared to domestic (3.06 kg) loins. No differences were observed for pH and cooking loss.

**Key Words:** Pork, Quality, Export

**81 Antemortem use of infrared thermography to predict pork quality.** T. E. Lawrence<sup>\*</sup>, M. F. Spire, M. E. Dikeman, M. C. Hunt, S. B. Hogge, and B. W. James, Kansas State University.

Currently, methods for identifying individuals or groups of pigs likely to result in PSE meat quality are not in commercial use. A proposed method is infrared thermography, which is a rapid, non-invasive procedure used to measure the surface temperature of an object without physical contact. Three experiments were conducted to determine if antemortem infrared measurements of surface temperature could segregate pigs based on subsequent pork quality. Pigs were classified subjectively as either hot (pigs with thermal images in the warmest  $1.5^\circ C$  of the temperature spectrum) or normal based on infrared surface temperature of the loin region. In the first experiment, pigs ( $n = 18$ ) were transported, imaged by infrared thermography, held in lairage for 1 to 4 h, and then slaughtered. Hot pigs ( $n = 4$ ) had less red 10th rib longissimus color than normal pigs ( $n = 14$ ) as indicated by lower ( $P < .05$ )  $a^*$  ( $5.1 \pm .27$  vs.  $6.8 \pm .51$ ) and chroma ( $14.8 \pm .55$  vs.  $16.4 \pm .30$ ) values, and higher ( $P < .05$ ) hue angle ( $69.9 \pm 1.72$  vs.  $65.4 \pm .92$ ) values. No differences between hot and normal pigs were detected for 45 min or 24 h pH, 45 min temperature, visual color score,  $L^*$ ,  $b^*$ , firmness, marbling, or percentage drip loss of 10th rib longissimus. In the second experiment, pigs ( $n = 27$ ) were transported, held in lairage for 12 to 16 h, imaged by infrared thermography, and then slaughtered. In the third experiment, pigs ( $n = 18$ ) were transported, imaged by infrared thermography, held in lairage for 12 to 16 h, and then slaughtered. Regardless of the time

antemortem that infrared images were taken, no meat quality differences between hot and normal pigs were detected after a 12 to 16 h lairage. These data indicate that measurement of surface temperature by infrared thermography may allow for detection of poor meat quality if pigs are slaughtered without extended lairage.

**Key Words:** Pork, Infrared Thermography, Meat Quality

**82 Influence of harvest processes on pork loin and ham quality.** M.A. Gardner<sup>\*1</sup>, S.M. Lonergan<sup>1</sup>, E. Huff-Lonergan<sup>1</sup>, L.J. Rowe<sup>1</sup>, and C.M. Schultz-Kaster<sup>2</sup>, <sup>1</sup>*Iowa State University*, <sup>2</sup>*Premium Standard Farms*.

The objective of this trial was to determine the impact of harvest processes on pork quality characteristics. Sixty-four Duroc X Yorkshire pigs were randomly assigned to a 2X2-treatment arrangement to determine the effect of the interval between sticking and scalding (dwell time 5 or 10 min) and duration of scalding (5 or 8 min) on pork loin and ham quality. All carcasses entered the cooler 50-min postmortem (PM). Blood was collected per minute for the first three minutes after sticking and total blood yield was determined after five minutes. Temperature and pH of the longissimus (LD) and semimembranosus (SM) were measured at 45 min, 2, 4, 6, and 24-h PM. Hunter L\*, a\*, and b\* values were determined on the LD, SM, and biceps femoris (BF). Purge loss was measured on the SM, BF, and the sirloin. Drip loss was measured from LD chops after 1 and 5 d of storage. Warner-Bratzler shear force (WBS) measurements were determined on LD chops aged 1, 3, 5, and 7 d PM. The first three minutes after sticking yielded 99.2% of the total collected blood. Temperature and pH of the LD and SM were not influenced by dwell time or scald time. Purge and drip loss values were not different among treatments. Hunter L\* values showed no treatment effects for the LD, SM, or BF. The 8 min scald treatment resulted in significantly higher ( $P < 0.01$ ) LD a\* values than the 5 min scald time. SM muscles in the 10 min dwell time treatment had significantly lower ( $P < 0.05$ ) b\* values than 5 min dwell times. BF muscles had significantly lower ( $P < 0.01$ ) a\* and b\* values in the 10 min dwell time compared to the 5 min treatment. The 10 min dwell time resulted in significantly higher ( $P < 0.02$ ) WBS measurements (d 1 and d 3) compared to the 5 min dwell time. The 8 min scald time resulted in significantly higher ( $P < 0.05$ ) WBS values (d 7) compared to the 5 min treatment. Dwell time and scald time did not influence overall pork quality when carcasses entered the cooler at the same time point PM. (Sponsored by the National Pork Board)

**Key Words:** Pork Quality, Harvest Process, Blood Yield

**83  $\mu$ -Calpain autolysis and calpastatin activity influences drip loss and tenderness of three porcine muscles.** J.L. Dodge\*, E. Huff-Lonergan, S.M. Lonergan, and L.J. Rowe, *Iowa State University Ames, Iowa*.

Accelerated  $\mu$ -calpain autolysis and lower calpastatin (CPST) activity were hypothesized to result in increased proteolysis and subsequently affect drip loss and meat tenderness. Halothane negative Duroc pigs (n=16) were harvested. Temperature and pH measurements were made on the longissimus dorsi (LD), semimembranosus (SM), and psoas major (PS) at 45 min, 6 h, 12 h, and 24 h postmortem (PM). Samples were taken from the LD, SM, and PS at 45 min, 6 h, and 24 h PM and extracted in 3 vols of 10 mM EDTA, 0.1%  $\beta$ -mercaptoethanol, 2 mM PMSF, 100 mg/L ovomucoid and 100 mM Tris, pH 8.3. After centrifugation, a portion of each supernatant was used for immunoblotting with an antibody against the  $\mu$ -calpain 80-kDa subunit. The remainder of the supernatant was used to determine CPST activity. Samples were collected from each muscle at 45 min, 6 h, 24 h, 48 h, and 120 h PM for examination of titin and nebulin by SDS-PAGE. Drip loss was measured on LD, SM, and PS chops taken at 24 h PM and held for an additional 24 h and 96 h at 4°C. Warner-Bratzler shear (WBS) force measures were evaluated on chops (LD, SM, and PS) at 24 h, 48 h, and 120 h PM. At 45 min, the PS had a significantly lower pH (5.50) than the LD (5.97) and SM (6.05) and had partial autolysis of the  $\mu$ -calpain 80-kDa subunit. All PS samples showed degradation of titin by 24 h PM. The PS had lower ( $P < .01$ ) drip loss (.87%) after 96 h of storage than the SM (2.23%) and LD (2.48%). The SM had higher ( $P < .0001$ ) WBS (5.37 kg) at 48 h PM than the LD (3.62 kg) and PS (3.73 kg). The SM had higher ( $P < .05$ ) CPST activity at 6 h (2.12 u/g tissue) and 24 h (2.09 u/g tissue) compared to the LD (1.86 u/g tissue at 6 h and 1.72 u/g tissue at 24 h) and PS (1.48 u/g tissue at 6 h and 1.41 u/g

tissue at 24 h). The LD also had higher ( $P < .05$ ) CPST activity than the PS at 6 h and 24 h PM. These results indicate differences between muscles in  $\mu$ -calpain autolysis, pH, and calpastatin activity play a role in the tenderness and drip loss of fresh pork products. (Supported by the National Pork Board).

**Key Words:** Pork, Drip Loss, Tenderness

**84 Descriptive analysis and consumer acceptance of irradiated beef patties.** J. L. Norman\*, C. L. Lorenzen, and H. Heymann, *University of Missouri-Columbia*.

The objectives of this study were to evaluate irradiated and non-irradiated beef patties of good and poor color using descriptive analysis and consumer panels. Samples were non-irradiated control, irradiated good color, and irradiated poor color. Good and poor color irradiated patties were batch processed together. All patties were frozen prior to packaging in individual, barrier vacuum pouches. Frozen patties were irradiated using electron beam technology at 1.0 kGy. University of Missouri personnel subjectively assigned color treatments in the raw state to patties. A trained descriptive analysis panel (n = 10) evaluated samples and generated verbal descriptors to depict sample differences. Attributes were rated on a 10-point unstructured line scale anchored on both ends. Significant attributes for the patties included red, gray, moist appearance and moist mouthfeel. Consumers (n = 94) were asked to rate patties for overall liking, liking of tenderness, liking of juiciness, and liking of flavor. Samples were rated on a nine-point sensory scale for liking where 1 = dislike extremely and 9 = like extremely. Irradiated patties were less gray and redder ( $P < 0.05$ ) in external appearance than patties not irradiated. Irradiated patties with poor color had a drier ( $P < 0.05$ ) surface appearance than non-irradiated controls and irradiated patties with good color. Irradiated patties with good color had a moister mouthfeel ( $P < 0.05$ ) than irradiated patties with poor color. Irradiated beef patties with good color had higher liking of juiciness ratings than non-irradiated control patties ( $P < 0.05$ ). However, no difference in liking of juiciness was detected between good and poor color irradiated patties ( $P > 0.05$ ). There were no treatment differences for overall liking of the beef patties ( $P > 0.05$ ). When panelists, descriptive and consumer, were not allowed to view the raw, uncooked beef patties few differences were found between the treatments.

**Key Words:** Beef, Irradiation, Color

**85 Improving foodservice consumer satisfaction of beef.** T. B. Schmidt\*, C. L. Lorenzen, and M. P. Keene, *University of Missouri - Columbia*.

The objectives of this study were to determine if visual and verbal aid and use of thermometers to determine end-point degree of doneness would improve consumer's liking of flavor (LFLAV), liking of juiciness (LJUIC), liking of tenderness (LTENDER), and overall liking (OLIKE) of beef steaks using a 9-point scale (1 = dislike extremely and 9 = like extremely). Consumers (n = 210) received a dinner to simulate a meal served in a medium priced steak house. Degrees of doneness on half of the steaks were determined using a thermometer; the others were determined by using the touch method. During two sessions, (n = 105) wait staff took the consumers order; during the remaining two sessions, (n = 105) wait staff provided the consumers with visual and verbal aid for the various degrees of doneness. Mean temperature of steaks ordered using the touch method was 67.6°C; the temperature served was 48.8 °C. Mean temperature of steaks ordered using the thermometers was cooked to 69.6 °C; the temperature served was 68.6 °C. Steaks cooked using the touch method were rated higher ( $P < 0.05$ ) for OLIKE, LTENDER, LJUCI, and LFLAV compared to those cooked using thermometers. Aided consumers rated OLIKE and LFLAV higher ( $P < 0.05$ ) compared to consumers with out aid. Steaks cooked to the appropriate degree of doneness were rated higher ( $P < 0.05$ ) for OLIKE and LFLAV than steaks over and (or) under cooked. Results show that steaks under cooked and (or) correctly cooked were higher ( $P < 0.05$ ) for LTENDER and LJUCI compared to steaks that were over cooked. The use of thermometers produced a more consistent in achieving more desirable end-point temperatures. However, consumers were more satisfied with steaks cooked using the touch method. Providing consumers with aid in selecting degree of doneness can improve consumer's satisfaction of steaks. Furthermore, results show that cooking steaks to the

degree of doneness ordered may improve consumer liking for OLIVE, LTENDER, LJUC, and LFLAV.

**Key Words:** Degree of Doneness, Consumer Satisfaction, Beef

**86 Cooking Rate Effects on Beef Tenderness, Cooking Losses, Sarcomere Length, and Collagen Solubility.** D. A. King\*, M. E. Dikeman, M. C. Hunt, and C. L. Kastner, *Kansas State University, Manhattan, KS.*

An experiment was conducted to evaluate the effects of cooking rate on tenderness, cooking losses, sarcomere length, and collagen solubility of beef *triceps brachii*, long head muscles. Muscles were excised from the right side of 12 carcasses at 24 h postmortem and cut into 2.54 cm thick steaks that were either frozen immediately or aged for 14 d. Steaks were cooked in a forced-air convection oven set at either 93° C (SLOW) or at 260° C (FAST) to an internal temperature of 70° C. Warner-Bratzler shear force, cooking losses, cook time, sarcomere length, total collagen, percent Ringer's soluble collagen, and enzyme resistant collagen were measured. The enzyme used was a non-specific protease of *Streptomyces griseus*. As expected, FAST cooking resulted in much shorter ( $P < 0.01$ ) cooking time, and increased ( $P < 0.01$ ) Warner-Bratzler shear force values compared to SLOW cooking (19.80 versus 100.84 min, and 5.04 versus 4.23 kg, respectively). Additionally, FAST cooked steaks had greater ( $P = 0.02$ ) cooking losses, and shorter ( $P = 0.03$ ) sarcomere lengths compared to SLOW cooked steaks. No differences were observed in total collagen, Ringer's soluble collagen, or enzyme resistant collagen. Aging for 14 d tended ( $P = 0.10$ ) to improve tenderness, but did not affect any other trait measured. Differences in tenderness created by cooking rate are often attributed to differences in collagen solubilization. However, in our study no differences in either total collagen or collagen solubility were observed. Thus, we suggest that the observed differences in Warner-Bratzler shear force are attributable to the greater cooking losses and reduced sarcomere lengths caused by FAST cooking. We further suggest that the increased cooking losses associated with FAST cooking could be explained by more severe shortening of collagen fibers, which likely compressed myofibrils and forced fluid expulsion.

**Key Words:** Beef, Tenderness, Cooking Rate

**87 Effects of cooking beef muscles from frozen or thawed on cooking traits and palatability.** E. Obuz\*, M. E. Dikeman, T. E. Lawrence, and E. J. Yancey, *Kansas State University Department of Animal Sciences and Industry.*

The objective of our study was to investigate the effects of cooking beef directly from a frozen versus thawed state on color, cooking time, cooking loss, and palatability attributes. Subprimals ( $n=20$ ) from USDA Choice beef carcasses were purchased, frozen 19-d postmortem and sawed into 2.54-cm thick longissimus lumborum (LL) and biceps femoris (BF) steaks. Steaks were cooked on a MAGiKitch'n electric belt grill at 93°C to the end-point temperature of 70°C. Cooking loss, cooking time, Warner-Bratzler shear force (WBSF), and color (Illuminant A,  $L^*$ ,  $a^*$ ,  $b^*$ ) were evaluated on each steak. Trained panelists ( $n=6$ ) evaluated palatability attributes on an 8-point scale for myofibrillar tenderness, juiciness, flavor, overall tenderness, and connective tissue amount (1= extremely tough, dry, bland, tough, and abundant; 8= extremely tender, juicy, intense, tender, and none). No significant differences ( $P>0.05$ ) in  $L^*$ ,  $a^*$ , WBSF, juiciness, flavor, connective tissue amount, or overall tenderness were found between steaks cooked from frozen (FS) and thawed state (TS). However, FS steaks required more cooking time ( $P<0.01$ ), had higher cooking loss ( $P<0.01$ ), lower  $b^*$  values ( $P<0.05$ ), and lower myofibrillar tenderness scores ( $P<0.05$ ) than TS steaks. The BF required more time to cook ( $P<0.05$ ), had more connective tissue ( $P<0.01$ ), lower flavor score ( $P<0.05$ ), higher WBSF ( $P<0.05$ ), was less tender ( $P<0.01$ ), and had higher post-cooking temperature rise ( $P<0.05$ ) than the LL. No differences in color, juiciness, or cooking loss were found. Cooking from the FS might be preferred over the TS because thawing is much faster, drip loss does not occur, and microbial growth risk associated with slow thawing may be reduced. However, higher cooking losses and a greater energy requirement might outweigh these advantages.

**Key Words:** Cooking, Frozen Versus Thawed, Tenderness

**88 Muscle satellite cell research in meat animals.** A. L. Grant\* and D. E. Gerrard, *Purdue University, West Lafayette, IN.*

Skeletal muscle satellite cells reside between the sarcolemma and basal lamina of myofibers. Representing a very small percentage of the total nuclei density of muscle tissue, satellite cells are responsible for postnatal myofiber DNA accretion, which accounts for more than one-half of the DNA accumulated after birth. Recruitment of satellite cell nuclei by myofibers is a requisite for postnatal muscle hypertrophy. Therefore, it is obvious why factors regulating activation, proliferation, differentiation, and ultimate fusion of satellite cells to myofibers in meat-animal muscle are being studied. Most studies, including those involving meat-animal muscle, have been performed using cell culture. To facilitate culture studies, fluorescence-activated cell sorting of muscle cells provides populations of satellite cells that retain the majority of replicative capacity and are not contaminated with non-myogenic cells. Such methodology is also ideal for studying sub-populations of satellite cells and for myoblast-mediated gene transfer in which these cells are used as vehicles for the delivery of foreign genes to skeletal muscle. Recruitment of satellite cells by myofibers likely requires tightly controlled expression of growth factors at appropriate times. Many of these growth factors exhibit paracrine and autocrine effects after being secreted by fibroblasts, myoblasts, myotubes, and myofibers. Because satellite cell recruitment involves activation of cells, followed by proliferation and differentiation before fusing with myofibers, hepatocyte growth factor and insulin-like growth factor-I are obvious candidates for regulating these processes. The extent to which muscle growth can be enhanced by stimulation of satellite cell activity has not been directly tested. Activating satellite cells and promoting proliferation and fusion is a strategy for investigating this in vivo. Models for accomplishing this may involve localized infusion of growth factor peptides into muscle, injection of DNA that encodes the growth factor of interest, or implantation of cells that over-express growth factors.

**Key Words:** Satellite Cells, Muscle, Growth Factors

**89 Recent advances in our understanding of skeletal muscle satellite cells.** J. Reecy\*, *Iowa State University, Ames.*

Skeletal muscles of mammalian species exhibit a remarkable ability to adapt to physiological demands such as growth, injury and training. This ability to adapt is largely attributed to a small population of cells, which reside within the skeletal muscle, termed satellite cells. The objective of this presentation is to review some of recent findings on the functional responses of satellite cells to physiological stimuli. Increased workload is a physiological stress that results in skeletal muscle hypertrophy. Load-induced hypertrophy involves satellite cell activation, proliferation, chemotaxis and fusion with the existing myofiber. However, the molecular mechanisms underlying these processes remain largely unknown. Recently, we reported on the changes in gene expression that accompany work overload induced skeletal muscle hypertrophy. Interestingly, we could classify the function of differentially expressed genes to each of these processes, suggesting that some adaptation occurs at the level of gene expression. Skeletal muscle hypertrophy does not occur in aged animals, suggesting a physiological adaptation with increasing age. Recent advances have suggested that the model utilized can greatly influence the results and conclusions obtained from an experiment. Under standard culture conditions, satellite cells obtained from aged rats proliferate at a slower rate and are capable of fewer rounds of replication. However, under conditions of reduced oxygen content, no observable difference in proliferation can be detected. These results demonstrate that experiments using traditionally accepted in vitro culture conditions might be flawed. Finally, recent studies have identified a population of pluripotent stem cells in skeletal muscle termed side population cells. These cells possess the ability to efflux the Hoechst dye, which distinguishes them from all other cells, which cannot efflux the dye. These cells are capable of differentiating into many other tissue types in vitro and in vivo. Since their discovery 40 years ago, we have learned a lot about satellite cells. However, we have only begun to examine the molecular mechanisms underlying the development and maintenance of satellite cells, satellite cell activation and proliferation, and potentiality.

**Key Words:** Skeletal Muscle, Satellite Cell, Muscle Growth



**90 How do satellite cells respond to mechanical changes in muscle?.** Ronald Allen\*<sup>1</sup> and R. Tatsumi<sup>2</sup>, <sup>1</sup>Univeristy of Arizona, <sup>2</sup>Kyushu University.

Satellite cells divide and differentiate during normal muscle growth and during repair, but they are quiescent for long periods of time. The work described here was designed to investigate how satellite cells are awakened from their quiescent state by mechanical changes in muscle such as stretch or damage. Cultured quiescent satellite cells were subjected to mechanical stretch in a FlexerCell System. In response to stretch, satellite cells entered the cell cycle earlier than if they were under control conditions. Only a brief period of stretch, as short as 2 hr, was necessary to stimulate activation. Additionally, conditioned medium from stretched cells could activate un-stretched satellite cells. The presence of HGF on c-met positive myogenic cells was detected by immunofluorescence at 12 hr in culture, and immunoblots demonstrated that HGF was released by stretched satellite cells into medium. Also, stretch activation could be abolished by the addition of anti-HGF antibodies to stretched cultures, and activity in conditioned medium from stretched cells could be neutralized by anti-HGF antibodies. In addition, stretch appeared to cause release of pre-existing HGF from the extracellular matrix. The stretch activation effect and the stretch-induced release of HGF from satellite cell extracellular domain occurred only over a narrow pH range with optimum activity around pH 7.2. The action of exogenous HGF, however, showed a broader range of pH dependence. Furthermore, the stretch-induced satellite cell activation effect and HGF release was inhibited by an inhibitor of nitric oxide synthase (NOS). It is interesting to note that NOS can be activated in muscle when mechanical changes in muscle fibers. These experiments suggest that HGF may be involved in linking mechanical perturbation of muscle to satellite cell activation and that this activity is mediated by NOS.

**Key Words:** Muscle, Satellite Cell, Growth Factor

**91 Repression of skeletal myogenesis by intracellular signaling modules that activate members of the MAPK family.** S.E. Johnson\*, S.R. Thomson, J.L. Page, S.A. Bolanowski, X. Wang, and C.M. Dorman, *The Pennsylvania State University.*

The formation of skeletal muscle is controlled, in part, by the intracellular transmission of external signals to the nucleus to affect gene transcription. A vast majority of growth factors and morphogens exert their effects through the induction of signaling pathways that culminate in mitogen-activated protein kinase (MAPK) activity. The MAPK family of signal transducers is comprised of ERK1/2, SAPK (or JNK) and p38. Overexpression studies clearly denote a negative impact of ERK1/2 on avian myogenesis. Retroviral misexpression of activated Raf alleles into avian myoblasts suppresses muscle gene expression and myofiber formation. These effects can be reversed by inhibition of MEK, the ERK1/2 activating kinase. Interestingly, Raf kinase also appears to signal through non-MEK dependent kinases to block myogenesis. MEK kinase I (MEKK1) strongly activates the JNK signaling pathway but also can interact with Raf and induce a modest level of ERK1/2 activity. However, the kinase does not participate in the Raf-imposed block to myogenesis, as coexpression of MEKK1 with dominant inhibitory Raf or MEK does not alleviate the repressive effects of the kinase. Thus, we conclude that chronic activation of components of the MEKK1/SEK/JNK and Raf/MEK/MAPK pathways result in biochemical and morphological disruption of the myogenic program independent of one another. However, the identities of the nuclear targets of the MAPK pathways that are responsible for the repression of skeletal myogenesis remain elusive. Our work demonstrates that the myogenic regulatory factors (MRFs) retain their inherent DNA binding capacity and are able to direct transcription from minimal E-box promoter reporter genes in cells directing high levels of ERK1/2 activity. In addition, myogenic cells constitutively expressing components of the MEKK1/SEK/JNK pathway demonstrate no detectable reduction in MRF-directed E-box transcription. As such, it is apparent that neither ERK1/2 nor JNK direct their inhibitory effects through disruption of intrinsic MRF function. Further work is required to define the means by which the MAPK family members perturb muscle-specific gene transcription and myocyte formation.

**Key Words:** MAPK, MRF, Skeletal Myogenesis

**92 Characterization of muscle glycogen storage and utilization: Influence on pork quality.** S. M. Lonergan\*, E. Huff-Lonergan, and M. F. Rothschild, *Iowa State University.*

Pork water holding capacity and color are dictated by the rate and extent of postmortem pH decline. The objective of this trial was to determine if differences in glycogen fractions or expression of glycogenin explain variation in the rate or extent of pH decline in pork longissimus. In experiment 1, 60 pork loins were collected at a commercial packing plant. Pork loins with the highest (n=12) and lowest (n=12) pH were grouped for analysis. Loin samples were aged 7 days prior to macroglycogen, proglycogen, and glucose determination. Glycogenin was evaluated using immunoblots. In experiment 2, 20 Berkshire x Yorkshire pigs were harvested. pH was measured at 2 and 24 hours postmortem. Macroglycogen, proglycogen, and glucose were measured in longissimus samples taken at 2 hours postmortem. In experiment 1, the low pH group had higher residual glucose and proglycogen than the high pH group. Immunoblots for glycogenin indicated a greater amount of glycogenin in samples with low ultimate pH. Since one glycogenin molecule remains covalently bound to the glycogen molecule, it is reasonable to hypothesize that the amount of glycogenin could be a limiting factor in determination of total glycogen in muscle and potentially ultimate pH in pork. In experiment 2, a greater proportion of the glucosyl units were detected with the macroglycogen fraction at 2 hours in samples that had a lower ultimate pH. Conversely, when a greater proportion of the glucosyl units were in the proglycogen fraction, a higher ultimate pH was attained. This indicates the rate of conversion of macroglycogen to proglycogen is related to ultimate pH. These results suggest that developing a more thorough understanding of glycogenin and glycogen metabolism in muscle and meat will aid efforts to improve overall quality of fresh pork. (Sponsored by the National Pork Board)

Group	High pH	Low pH	P value		
	(n=12)	Group (n=12)			
	Mean	S.E.	Mean	S.E	
pH	6.04	0.07	5.47	0.05	
Glucose $\mu$ M/g					
tissue	4.7	0.3	35.4	3.0	<.01
Proglycogen $\mu$ M/g					
tissue	0.96	0.15	5.92	0.25	<.01
Macroglycogen $\mu$ M/g					
tissue	0.10	0.04	0.10	0.04	.87

**Key Words:** Glycogenin, Glycogen, Pork Quality

**93 Performance of growing-finishing pigs in pens with low or high variation in body weight.** B. F. Wolter\*<sup>1</sup>, M. Ellis<sup>1</sup>, S. E. Curtis<sup>1</sup>, B. P. Corrigan<sup>1</sup>, J. M. DeDecker<sup>1</sup>, E. N. Parr<sup>2</sup>, and D. M. Webel<sup>2</sup>, <sup>1</sup>University of Illinois, Urbana, <sup>2</sup>United Feeds, Sheridan, IN.

It is common practice to double-stock wean-to-finish buildings for an initial period post-weaning to increase total weight of pigs produced in a building. The objective was to investigate the effect of body weight (BW) variation within a pen after double-stocked pens of pigs were split into two groups on pig performance to slaughter (112 SD = 2.2 kg). A randomized block design was used with three treatments. At weaning, pigs (n = 1,728) were double-stocked in a wean-to-finish building in groups of 108 pigs. At the end of wk 8 post-weaning, pens were split into two mixed-sex (equal ratio of barrows to gilts) groups of 54 animals to give three treatments: 1) Low range in BW (6.3% CV) with Heavy mean BW (34.2 kg; n = 8), 2) Low range in BW (7.6% CV) with Light mean BW (28.6 kg; n = 8), and 3) High range in BW (10.7% CV) with Intermediate mean BW (31.1 kg; n = 16). Floor- and feeder-space allowances (0.60 m<sup>2</sup>/pig and 4 cm/pig), and drinker allocation (14 pigs/drinker) were the same for all treatments. Pigs had free access to feed and water. Pen-BW treatment did not impact ADG (792, 775, and 780 10.9 g for treatment 1, 2, and 3, respectively; P > 0.05) or gain:feed ratio (0.34, 0.35, and 0.34 0.009; P > 0.05), but ADFI (2375, 2244, and 2301 17.1 g) was higher for Trt 1 compared to Trt 2 with pigs in Trt 3 being intermediate and different (P < 0.01) from the other treatments. At 112 kg BW, CV of BW within a pen was similar (P > 0.05) across treatments and there was no treatment effect (P > 0.05) on backfat or loin depths. However, days to reach 112 kg BW increased with decreasing initial BW (96.9, 105.5, and 102.4 1.4 days; P < 0.01). In summary, reducing variation in BW when splitting double-stocked wean-to-finish pens at wk 8 post-weaning did not impact growth or feed

efficiency during the growing-finishing period, although, pens of pigs that were heavier at the end of wk 8 post-weaning required fewer days to reach slaughter.

**Key Words:** Pigs, Body Weight, Wean-to-Finish

**94 Effects of feed form and placement immediately postweaning on the growth performance of piglets.** B. P. Corrigan\*, M. Ellis, B. F. Wolter, J. M. DeDecker, and S. E. Curtis, *University of Illinois, Urbana IL/USA.*

This study evaluated effects of providing feed as a gruel and feeding on floor mats on pig performance for three weeks postweaning. It was carried out in a commercial wean-to-finish facility and used a randomized complete block design with a 2 # 2 factorial arrangement with treatments being feed form (dry-pellet vs gruel [1:1 water to pellet ratio]) and feed placement (in the feeder trough only vs on the floor mat and in the feeder trough). Treatments were applied for 4 d postweaning and consisted of feed delivery four times per d (0600, 1000, 1400, and 1800 h). In addition, pigs had ad libitum access to water and pelleted starter feed. Pigs (n=864) were allotted at weaning (4.9  $\pm$  0.02 kg BW; 17  $\pm$  2 d of age) to pens of 27 animals on the basis of sex (equal ratio of barrows to gilts) and weight. Floor, feeder-trough, and mat spaces were 0.64 m<sup>2</sup>, 2.26 cm, and 0.05 m<sup>2</sup>/pig, respectively. Pig BW was taken at the start, end of wk 1, and end of study (wk 3), and feed disappearance measured at end of wk 1 and 3. Feed form did not affect (P>0.05) growth rate, however, feed disappearance was higher (P<0.05) in wk 1 (216 vs 180 8.4 g) and from wk 1 to 3 (328 vs 289 10.8 g) for the gruel, and there was a trend (P=0.10) for a decreased gain:feed ratio (0.595 vs 0.660 0.0226) for gruel fed pigs. Feeding pigs on the mat and at the trough compared with trough only resulted in greater growth rate (92 vs 76 4.6 g; P<0.05) in wk 1, increased feed disappearance during wk 1 (246 vs 150 8.4 g; P<0.001) and for wk 1 to 3 (331 vs 286 10.8 g; P<0.05), and tended (P=0.06) to increase growth rate (197 vs 186 3.3 g) for the study period. There was a significant (P<0.05) interaction between feed form and feed location for gain:feed during wk 1. For pigs fed on the mat and at the trough, there was no effect of gruel vs dry feed on gain:feed (0.371 vs 0.387 0.0273); in contrast, for pigs fed only at the trough, gain:feed was substantially greater with the dry compared to the gruel (0.622 vs 0.395 0.0273). However, feed efficiency for the overall study was not affected (P>0.05) by feed location. Results suggest providing newly-weaned pigs access to feed on floor mats and feeder troughs increased growth rate initially after weaning, however, gruel feeding produced no improvement in weight gain.

**Key Words:** Weaning, Pigs, Feed Management

**95 Effect of excess dietary leucine on growth and carcass characteristics, intramuscular fat level, and pork quality in finishing pigs.** Y. Hyun\*, M. Ellis, and F. McKeith, *University of Illinois at Urbana-Champaign.*

Previous research has suggested that feeding excess dietary leucine to finishing pigs increased intramuscular fat levels and improved muscle color. This study was conducted to validate this finding. A completely randomized design using a 2 X 2 factorial arrangement of treatments was used. The treatments were: 1) dietary leucine level (normal [1.22 %] vs high [3.22 %]) and 2) gender (barrows vs gilts). Forty crossbred pigs (Duroc x Yorkshire) were reared from 78.4  $\pm$  3.5 to 114.8  $\pm$  7.3 kg BW over a 39 day study period. Pigs were housed and fed individually in fully slatted pens that provided 1.6 m<sup>2</sup>/pig of floor space. Temperature in the building averaged 21.2  $\pm$  3  $^{\circ}$ C over the study period. Pigs were given ad libitum access to feed and water. Diets were formulated using corn and soybean meal to meet or exceed the nutrient requirements recommended by NRC (1998). The high leucine diet contained 13.2 % CP, 0.79 % lysine, 1.22 % leucine and 3,420 kcal ME/kg, and the normal leucine diet contained 15.2 % CP, 0.79 % lysine, 3.22 % leucine and 3,400 kcal ME/kg. At 24-h postmortem, carcass and meat quality evaluation was carried out. Carcass measurements included carcass weight, midline and 10th rib fat depth and 10th rib loin eye area. Pork quality measurements were taken on the longissimus and included subjective color, firmness, marbling scores (scale: 1 = pale, soft and devoid of marbling to 5 = dark, firm and abundant or greater marbling), Hunter color (L\*, a\* and, b\*), drip loss, and fat and water content. Pigs fed high compared with the normal leucine level were lighter (111.1 vs 115.4 kg, sem 1.39; P < 0.05) at the end of study, and grew more slowly (829 vs 930 g/d, sem 32.2; P < 0.05). However, the high leucine level

increased marbling score (3.9 vs 3.2, sem 0.24, P < 0.05) and muscle fat content (3.4 vs 2.4 %, sem 0.33; P < 0.05) compared to the normal leucine level. There was no effect of dietary leucine level on other meat quality measurements. As anticipated barrows grew faster, were fatter, and had higher marbling and intramuscular fat levels and firmer muscle scores than gilts. The results of the present study suggest that feeding excess leucine increased intramuscular fat content but reduced growth rates and had no effect on muscle color.

**Key Words:** Leucine, Meat Quality, Finishing Pigs

**96 Effect of a step-up or step-down ractopamine sequence on carcass primal cut weights.** A. P. Schinckel\*, C. T. Herr, D. C. Kendall, K. A. Bowers, S. L. Hankins, T. E. Weber, and B. T. Richert, *Purdue University; West Lafayette, IN.*

One-hundred sixty pigs, 80 barrows (B) and 80 gilts (G) with an initial BW of approximately 71.9  $\pm$  3.8 kg were allotted by sex and weight to evaluate the effect of feeding a constant or a phase feeding treatment (TRT) of varying ractopamine (RAC) levels on growth performance and carcass traits. Pigs were fed one of four dietary TRT for 42 days. Treatments were as follows: 1) Control diet containing no RAC wk 0-6; 2) Step-down RAC sequence: 20 ppm RAC wk 1 and 2, 10 ppm RAC wk 3 and 4, and 5 ppm RAC wk 5 and 6; 3) Step-up RAC sequence: 5 ppm RAC wk 1 and 2, 10 ppm RAC wk 3 and 4, and 20 ppm RAC wk 5 and 6; and 4) Constant RAC, 11.6 ppm wk 0-6. A 19.6% CP diet, 1.2% lys, and an 18.5% CP diet with a 1.1% lys level were fed to G and B respectively. One side of the carcasses from a subset of 64 pigs (16/TRT) was fabricated into primal and trimmed subprimal cuts and weighed. The four major muscles of the ham were dissected and weighed. The step-up and constant TRT had greater (P < .05) carcass weight (91.4 and 90.3 kg) than the step-down or control TRT (87.2 and 84.5 kg). All RAC pigs had greater (P < .05) rough cut shoulder weight than control pigs. Pigs of the step-up and constant TRT had greater (P < .05) rough cut ham and loin weights than the control pigs. Step-up and constant pigs had greater (P < .05) boneless trimmed loin weight (11.3 and 11.1 kg) than the step-down and control pigs (10.6 and 10.3 kg). Rough cut ham weights were greater (P < .05) for the step-up and constant TRT (11.9 and 11.7 kg) than the step-down (11.0 kg) and control (10.5 kg) TRT. Total ham lean, bicep femoris and quadriceps femoris weights were similar for the step-up and constant TRT and greater (P < .05) than the step-down TRT, which in turn was greater (P < .05) than the control TRT. Dietary RAC TRT did not affect (P > .05) rough cut belly weight, trimmed belly weight, sparerib weight or baby back rib weight. The step down program had reduced carcass lean cut and muscle weight compared to the step-up and constant TRT.

**Key Words:** Finishing Pigs, Ractopamine, Carcass Composition

**97 Effect of ractopamine and dietary crude protein on carcass cut and tissue weights.** A. P. Schinckel\*, C. T. Herr, D. C. Kendall, and B. T. Richert, *Purdue University; West Lafayette, IN.*

Ninety-six barrows (initial BW 69.6  $\pm$  4.0 kg) were allotted by weight to evaluate the effects of dietary lysine levels while feeding ractopamine (RAC) on growth performance and carcass traits. Treatments (TRT) 1 and 2 were fed throughout the six-week trial, while TRT 3 changed weekly. Treatments were as follows: 1) 16% CP, .82% lys control diet; 2) 16% CP diet, .82% lys; 3) a phase fed diet sequence, 18% CP, 1.08% lys during wk 1 and 4, 20% CP, 1.22% lys during wk 2 and 3, 16% CP, .94% lys during wk 5, and a 16% CP diet .82% lys during wk 6. All diets in TRT 2 and 3 contained 20 ppm RAC. Diets for TRT 3 were designed to meet the estimated lys requirements based on the modeled RAC lean growth from previous research. Pigs were marketed when the block weight reached 108.8 kg. The right sides of carcasses from pigs (n = 15/TRT) were fabricated to determine rough and trimmed cut weights. The four major cuts (ham, loin, picnic, Boston butt) were dissected into fat and muscle tissue. Pigs fed RAC had increased rough (9.55, 10.29, 10.82; P < 0.05) and trimmed ham (8.97, 9.74, 10.11 kg; P < 0.05, TRT 1-3 respectively), loin (7.62, 7.81, and 8.26 kg; P < 0.05), and Boston butt weight (4.15, 4.32, 4.70 kg; P < 0.05). Pigs fed RAC had greater dissected lean in the ham (6.30, 7.10, 7.48 kg; P < 0.05), loin (5.13, 5.47, 5.87; P < .05), Boston butt (2.94, 3.24, 3.64; P < 0.01) and four major cuts (16.57, 18.08, 19.35 kg; P < 0.01). Overall, RAC decreased the dissected fat tissue in the four lean cuts (7.18, 6.68, and 6.21 kg; P < .05). The weight of the semimembranosus (1.47, 1.61, 1.76

kg;  $P < .01$ ) and semitendinosus muscles (0.45, 0.52, 0.56 kg;  $P < .05$ ) was increased by RAC. In general, the RAC response for TRT 2 was less than TRT 3. The data indicate that the response of RAC to alter carcass cut, muscle, and fat weight is dependent on both dietary RAC and lysine levels.

**Key Words:** Pigs, Carcass Composition, Ractopamine

**98 A three year summary of finishing pig performance in hoop structures and confinement during winter and summer in Iowa.** M. S. Honeyman, J. D. Harmon, and A. D. Penner\*, *Iowa State University*.

Six trials (three summer and three winter) were conducted over three years with 3,517 pigs. The objective was to compare the performance of finishing pigs in hoop structures during summer and winter in Iowa with pigs in confinement. For each trial, three groups of pigs were placed in three (9.1m x 18.3m) cornstalk bedded hoop structures (150 pigs per group). The fourth group was in six pens in a mechanically ventilated confinement building with slatted floors (22 pigs/pen). The pigs weighed 16 kg at the start of the trials and were fed corn-soy diets in phase until weighing 118 kg. The pigs were scanned at 112 kg. Overall, the pigs in hoop structures ate 5% more feed ( $P < 0.001$ ), grew 2% faster ( $P < 0.01$ ), and were 4% less efficient than pigs in confinement ( $P < 0.001$ ). Overall, the pigs in hoop structures had 4.4% more backfat ( $P < 0.05$ ), 4.7% smaller loineyes ( $P < 0.001$ ), and lower yield (0.9 percentage units) than pigs in confinement. Bedding use was 92 kg/pig in summer and 122 kg/pig in winter. In summer, pigs in hoop structures ate 3.1% more feed ( $P < 0.01$ ), grew 4.0% faster ( $P < 0.001$ ), had 7.4% more backfat ( $P < 0.01$ ), but did not differ in feed efficiency or loineye size compared to the pigs in confinement. In winter, the pigs in hoop structures ate 6.7% more feed ( $P < 0.01$ ), and had 7.1% poorer feed efficiency ( $P < 0.05$ ), but there was no difference in growth rate, backfat thickness or loineye size compared to the confinement pigs. The hoop environment (both seasons) encouraged the pigs to consume more feed, and during the winter caused the pigs to use more of the feed energy for maintaining body temperature rather than for growth. Hoop pig mortality was lower in summer (1.8 vs. 2.7%) but higher in winter (3.8 vs. 2.3%) compared to confinement. The percentage of cull and light pigs was similar in the summer (2.5 vs. 2.7%) but was higher in the hoops for winter (5.5 vs. 2.3%). This may have been due to the larger hoop group size and the much colder winter hoop environment. Research is needed to improve feed efficiency and leanness of pigs in hoop structures.

**Key Words:** Finishing Pig Performance, Bedded Hoop Structures, Pig Leanness

**99 The muscle cell intermediate filament protein synemin interacts with the universal cytolinker plectin.** D. Walker\* and R. Robson, *Iowa State University*.

Determining the nature of the complex interactions of the cytoskeletal proteins within muscle cells is essential to our understanding of developing muscle. Synemin is a large (183 kD) member of the intermediate filament (IF) protein superfamily and is present primarily in muscle cells. We have shown previously that synemin interacts with other members of the IF superfamily such as desmin and vimentin, and with cytoskeletal proteins at the costameres and myofibrillar Z-lines, helping to provide the mechanical stability essential in muscle cells. In this study we tested the hypothesis that synemin also interacts with the large universal cytolinker protein plectin, thereby contributing to the formation of a network of linkages extending from the sarcolemma to the Z-lines of the peripheral layer of myofibrils and between Z-lines of neighboring myofibrils. Plectin (300 kD by SDS-PAGE) has been shown in mammalian cells to be a widely expressed, multifunctional protein capable of interconnecting different cytoskeletal filaments and other components such as IFs and desmosomes. Using antibodies known to cross-react with plectin in cells of several different mammals and on Western blots, we show for the first time that plectin is also present in several avian tissues, and migrates at 300 kD by SDS-PAGE. Immunofluorescent labeling of chicken myofibrils with anti-plectin antibodies showed strong labeling at the Z-lines, consistent with the localization of plectin in mammalian striated muscle. Tissue-purified synemin was shown to interact with a bacterially expressed domain of plectin by gel blot overlay assays. The interaction between plectin and synemin should provide an important additional structural linkage involving the IFs between the Z-lines of adjacent myofibrils and between the peripheral myofibrils and

the costameric sites located along the sarcolemma, thus providing the integrity needed for promoting the efficient growth and development of muscle. (Supported by USDA-NRICGP 99-35206-8676)

**Key Words:** Muscle Cell Cytoskeleton, Intermediate Filaments, Plectin

**100 The effect of initial stocking rate on pig performance in a wean-to-finish system.** J. M. DeDecker\*, M. Ellis, B. F. Wolter, B. P. Corrigan, S. E. Curtis, and G. R. Hollis, *University of Illinois, Urbana*.

Double stocking of wean-to-finish facilities for a period after weaning is an approach being used by producers to increase weight of pigs produced from a given facility. This study evaluated the effect of double stocking for a 10-wk period post-weaning on growth performance from weaning to slaughter weight. Pigs ( $n=1,458$ ) were used in a randomized block design to compare two stocking rate treatments (Single [27 pigs/pen] vs Double [54 pigs/pen]) on pig performance from weaning (4.8 0.004 kg BW; approximately 15 1 day of age) to 24 wk post-weaning (113.7 0.74 kg BW). Floor and feeder spaces per pig were 0.64 m<sup>2</sup> and 3.4 cm and 0.32 m<sup>2</sup> and 1.7 cm for the single- and double-stocked pens, respectively. At the end of wk 10 post-weaning, double-stocked pens of pigs were split into two equal-sized groups with similar mean BW and CV of BW, and one of the groups was moved to a different identical pen within the room. Therefore, from 10 to 24 wk, three treatments were compared: single-stocked, pigs remained in the same pen (single-stocked) vs double-stocked, pigs remained in same pen after splitting the pen (double-stayed) vs double-stocked, pigs moved to new pen after splitting the pen (double-moved). Pigs had free access to feed and water. In the first 10 wk post-weaning, double- compared to single-stocking resulted in a lower ADG (7.9%;  $P<0.001$ ) and lighter pigs (7.3%;  $P<0.001$ ). From wk 10 to slaughter, pigs previously housed at double- compared to single-stocking rate had similar ( $P>0.05$ ) growth rates (772, 767, and 767 8.1 g for single-stocked, double-stayed, and double-moved, respectively) but, were lighter (116.6, 112.6, and 112.0 0.74 kg BW;  $P<0.001$  for single-stocked, double-stayed, and double-moved, respectively) at end of wk 24 post-weaning. Moving double-stocked animals to a new pen at the end of wk 10 did not impact ( $P>0.05$ ) subsequent growth rates (767 vs 767 9.4 g for double-stayed and -moved, respectively). Coefficient of variation in pig BW within a pen were similar ( $P>0.05$ ) among stocking rates at wk 10 and wk 24. Mortality and morbidity were similar from start to wk 10 and from wk 10 to slaughter. In support of previous findings, double stocking reduced growth rate to 10 wk post-weaning, but did not impact subsequent growth, and therefore, resulted in lighter pigs at 24 wk post-weaning.

**Key Words:** Pigs, Stocking Rate, Wean-to-Finish

**101 The effect of group size/floor space allowance on pig performance in a wean-to-finish production system.** J. M. DeDecker\*, M. Ellis, B. F. Wolter, B. P. Corrigan, S. E. Curtis, and G. R. Hollis, *University of Illinois, Urbana*.

A key decision relating to facility management is how many animals to place in a specific building. Historical research to optimize group size/floor space relationships was based on multiple-phase systems. This experiment was carried out to establish the relationship between group size/floor-space allowance on growth performance in a wean-to-finish production system. Pigs ( $n = 1,296$ ) were used in a randomized complete block design to evaluate three group size treatments (22, 27, and 32 pigs/pen) on growth performance from weaning (5.0 0.01 kg BW; 15 1d of age) to 18 wk post-weaning. Floor and feeder spaces per pig were 0.78 m<sup>2</sup> and 4.2 cm, 0.64 m<sup>2</sup> and 3.4 cm, 0.54 m<sup>2</sup> and 2.9 cm for group sizes of 22, 27, and 32 pigs, respectively. Pigs had free access to feed and water. Pigs were weighed at start, wk 8, and wk 18 post-weaning. Group size did not impact ( $P > 0.05$ ) pig performance during the first 8 wk post-weaning. Therefore, pig BW were similar ( $P > 0.05$ ) among all treatments at end of wk 8. However, during the period from wk 8 to wk 18 post-weaning ADG decreased ( $P < 0.001$ ) with increasing group size (894, 851, and 829 8.8 g for 22, 27, and 32 pigs/pen, respectively). For the overall study (start to wk 18) both ADG and BW were increased ( $P < 0.001$ ) with decreasing group size. At end of 18 wk post-weaning, the coefficient of variation in pig BW within a pen and morbidity and mortality (removal rate) were similar among stocking rates. In conclusion, decreasing group sizes, thereby, increasing floor- and feeder-space allowance per pig increased growth rate after 8 wks post-weaning resulting in heavier pigs at 18 wk post- weaning for the smaller groups.

Group size	22	27	32	SEM
BW at start, kg	5.0	5.0	5.1	0.01
BW at 8 wk, kg	35.1	34.7	34.3	0.30
BW at 18 wk, kg	90.9	87.6	85.6	0.70*
ADG overall, g	676	650	633	5.3*
Removal rate, %	2.0	1.4	2.6	0.54

\* Significant group size effect ( $P < 0.001$ )

**Key Words:** Pigs, Group size, Wean-to-finish

### 102 Effects of Sex and Market Weight on Growth Performance, Carcass Characteristics and Pork Quality. B. G. Kim\*, J. R. Piao, Y. Y. Kim, and In K. Han, *Dept. of Anim. Sci. & Tech., Seoul National University.*

An experiment was conducted to examine the effect of sex and market weight on the carcass characteristics and pork quality. A total of 224 crossbred pigs (initial body weight = 26.6 kg) were allotted in a 2 x 4 factorial arrangement in a randomized complete block design. There were two sexes (112 gilts and 112 barrows) and four market weights (100, 110, 120 and 130 kg). Average daily gain (ADG) and average daily feed intake (ADFI) were higher significantly ( $p < 0.01$ ) in barrows than gilts, ADFI and feed conversion ratio (FCR) were increased linearly as body weight increased ( $p < 0.01$ ). Gender differences were observed in carcass characteristics. Backfat and drip loss were greater in barrows ( $p < 0.01$ ) however, loin eye area, flavor score and lean content were higher in gilts ( $p < 0.01$ ) regardless of body weight. Carcass grade and water holding capacity were the highest in 110 kg market weight pigs. The 100 kg market weight pigs showed lower juiciness, tenderness, shear forces and total palatability than the other market weights ( $p < 0.01$ ). Hunter values ( $L^*$ ,  $a^*$  and  $b^*$ ) were increased as market weight increased ( $p < 0.05$ ). Hunter  $a^*$  value was greater in gilts ( $p < 0.01$ ) but  $L^*$  and  $b^*$  were not affected by sex of pigs. Net profit[(carcass weight x price by carcass grade)-total feed cost] was higher in gilts than barrows ( $p < 0.01$ ), and was the highest in 110 kg market weight ( $p < 0.01$ ). These results demonstrated that gilts showed higher carcass characteristics, pork quality, feed cost/kg body weight gain and net profit compared to barrows. Body weight of 110 kg is recommended to maximize pork quality and profit.

**Key Words:** Sex, Market Weight, Pork Quality

### 103 The effect of feeding ractopamine on growth and carcass traits in three genetic lines of pigs. T. J. Baas\*, S. J. Moeller<sup>2</sup>, C. D. Johnson<sup>1</sup>, H. Zerby<sup>2</sup>, G. M. Stoller<sup>2</sup>, and L. E. Watkins<sup>3</sup>, <sup>1</sup>Iowa State University, <sup>2</sup>The Ohio State University, <sup>3</sup>Elanco Animal Health.

The influence of genetic line and gender on responses of pigs to ractopamine hydrochloride (RAC) on growth, efficiency, and carcass traits was determined in this study. Berkshire ( $n = 76$ ), Duroc ( $n = 81$ ), and high-lean (HL) commercial crossbred ( $n = 75$ ) barrows and gilts were allocated to be fed standard commercial diets supplemented with RAC at 0 or 10 ppm. Pigs were started on the experimental diet at approximately 85.1 kg and remained on test for a period of 28 d. Traits were grouped as growth, carcass, and feed utilization traits. Genetic line, gender, treatment, and all two-way interactions were included as independent variables initially in all statistical models. Interactions were removed from subsequent analyses of dependent variables only if all dependent variables within a group of traits were not significant. Average daily gain (ADG) was evaluated over these periods: entry to market, start of grow-finish period to start of RAC feeding period, start of grow-finish period to market, week 1 on RAC, weeks 1 to 2 on RAC, weeks 1 to 3 on RAC, and start of RAC feeding period to market (weeks 1 to 4). Average entry and market weights in this trial were 4.9 kg and 111.4 kg, respectively. Feed efficiency (FE) and average daily feed intake on a pen basis were recorded for week 1, weeks 1 to 2, weeks 1 to 3, and for the entire 4-week RAC feeding period. Pigs were harvested and carcass measurements taken at 24 h post-mortem. Pigs fed RAC had increased average daily gain ( $P < 0.01$ ), produced more gain per unit of feed ( $P < 0.01$ ), and produced carcasses with more loin muscle area ( $P < 0.05$ ). The response to RAC for ADG and FE was similar for all three genetic lines. Ractopamine reduced tenth rib backfat in HL pigs but a response was not evident in Duroc and Berkshire pigs. It appears RAC is a good

tool to improve the performance and carcass composition of industry genetic lines.

**Key Words:** Ractopamine, Growth, Carcass Composition

### 104 The relationship between serum leptin concentration and beef carcass composition and quality. E. L. McFadin\*, D. H. Keisler, T. B. Schmidt, C. L. Lorenzen, and E. P. Berg, *University of Missouri.*

The protein hormone product of the ob gene, leptin, has been implicated in the control of food intake and body composition. The principal site of leptin production is the adipocyte and thus circulating concentrations of leptin have been positively correlated with body fat mass. Steers of various genotypes from the 2001 Missouri State Beef carcass contest were used to evaluate the relationship between serum concentrations of leptin and beef carcass composition and quality traits collected under normal commercial slaughter conditions. Cattle were shipped to a large-scale commercial beef packing plant where serum samples were obtained from steers during exsanguination. Carcass data including hot carcass weight ( $343.92 \pm 3.5$  kg), adjusted 12<sup>th</sup> rib fat thickness ( $0.93 \pm 0.049$  cm), percentage kidney, pelvic and heart fat ( $2.10 \pm 0.053$  %), marbling score ( $38.76 \pm 0.95$  marbling score units) and overall yield grades ( $2.29 \pm 0.86$  yield grade units) were obtained online by trained evaluators from the University of Missouri. Serum concentrations of leptin concentrations were determined using a leptin radioimmunoassay validated for use in our lab. Leptin concentrations were significantly correlated to fat thickness over the 12<sup>th</sup> and 13<sup>th</sup> rib, marbling score, calculated yield grade and calculated boneless, closely trimmed retail cuts ( $r = 0.34$ ,  $P = 0.001$ ;  $r = 0.19$ ,  $P = 0.08$ ;  $r = 0.26$ ,  $P = 0.02$ ;  $r = -0.20$ ,  $P = 0.08$ , respectively). Leptin was not correlated with hot carcass weight, ribeye area or percentage kidney, pelvic and heart fat ( $r = 0.16$ ,  $P = 0.14$ ;  $r = 0.11$ ,  $P = 0.31$ ;  $r = 0.13$ ,  $P = 0.24$ , respectively). We conclude that serum concentrations of leptin can be used to objectively assess whole carcass composition in fed cattle and may provide a means by which carcass quality can be predicted in the live animal.

**Key Words:** Leptin, Composition, Quality

### 105 Protein accretion in pigs infected with *Mycoplasma hyopneumoniae* and Porcine Reproductive and Respiratory Syndrome Virus. J. Escobar\*, T. L. Toepfer<sup>1</sup>, W. G. Van Alstine<sup>2</sup>, D. H. Baker<sup>1</sup>, and R. W. Johnson<sup>1</sup>, <sup>1</sup>University of Illinois, Urbana, IL, <sup>2</sup>Purdue University, W. Lafayette, IN.

Although *Mycoplasma hyopneumoniae* (Mh) and Porcine Reproductive and Respiratory Syndrome Virus (PRRSV) are thought to depress growth performance, it is not known if they interact, or how they activate the immune system to impair growth. The objectives of this study were to evaluate the effects of Mh and PRRSV-when presented either alone or in combination-on growth performance in nursery pigs, and to determine if growth was negatively correlated with serum levels of interleukin (IL)-1 $\beta$  and IL-6. Sixty-four pigs were subjected to one of four treatment combinations (2 X 2 factorial) of Mh [intratracheal inoculation with Friis or P5722-3 ( $3 \text{ ml } 10^7 \text{ cfu/ml}$ ) at 4-wk of age] and PRRSV [intranasal inoculation with DMEM or VR-2385 ( $5 \text{ ml } 10^5 \text{ 50\% TCID}_{50}$ ) at 6-wk of age]. FI, ADG and G:F ratio were determined postinoculation. One half of the pigs were killed 7 d after PRRSV inoculation and the remaining pigs were killed 7 d later. Whole-body CP was determined to estimate protein accretion (PA). IL-1 $\beta$  and IL-6 were measured in sera collected 7 d after PRRSV inoculation using porcine-specific ELISA. Two-way ANOVA of FI, ADG, PA, IL-1 $\beta$  and IL-6 detected a main effect of PRRSV ( $P < 0.001$ ), but neither the Mh effect nor the Mh # PRRSV interaction were significant. Mh-induced lung lesions, however, were 3 to 5 times greater ( $P < 0.001$ ) in pigs with both Mh and PRRSV than in those with Mh alone. PRRSV induced a marked increase in both IL-1 $\beta$  and IL-6, and a concomitant decrease ( $P < 0.001$ ) in FI, ADG and PA. There was a negative correlation ( $P < 0.001$ ) between IL-1 $\beta$  and ADG ( $r = -0.72$ ), FI ( $r = -0.80$ ) and PA ( $r = -0.72$ ); IL-6 was negatively correlated ( $P < 0.001$ ) with ADG ( $r = -0.83$ ) and PA ( $r = -0.71$ ). Collectively, these data suggest that the acute effects of PRRSV infection on FI and growth are independent of Mh infection. Furthermore, they suggest that the reduced FI and growth in sick pigs may depend on increased circulating levels of inflammatory and metabolically active cytokines like IL-1 $\beta$  and IL-6.

**Key Words:** Inflammatory Cytokines, Growth, Mycoplasma and PRRSV

**106 The use of nonlinear mixed models for swine growth.** A. P. Schinckel\* and B. A. Craig, *Purdue University, West Lafayette, IN.*

Alternative versions of a three-parameter nonlinear growth function (Bridges, 1986;  $BW_{i,t} = C(1 - \exp(-M t^A)) + \text{birthweight} + e_{i,t}$ , where  $t$  is days of age for the  $i$ th pig) were evaluated on two groups of gilts. The gilts were randomly assigned to be reared under all-in, all-out (AIAO,  $n = 96$ ) or continuous flow management (CF,  $n = 96$ ). The fixed effects version assumes the BW of each pig deviates from the BW growth function and that these deviations (i.e., residuals) are independent with constant variance. Empirically, these assumptions are not reasonable. As an alternative, we propose the use of random effects and investigate both one and two random effect models. The inclusion of random effects provides a flexible method to better reproduce the underlying variance-covariance structure of the serial live weights while still assuming the residuals are independent with constant variance. These models are also easily adaptable to stochastic modeling. For these data, the AIC (Akaike's Information Criteria) values for the fixed effects model were 2176 and 4116 for the AIAO and CF gilts. By allowing the mature body weight to vary pig to pig (i.e.,  $C + c_i$ ) the AIC values are reduced to 1904 and 3633 respectively, and the RSD's, the standard errors of the  $M$  and  $A$  parameters were reduced by over 50%. The addition of a second random effect for  $M$  (i.e.,  $M + m_i$ ) further reduced the AIC values (1883, 3568 for AIAO and CF) and the RSD's. The inclusion of the second random effect accounts for different patterns of growth between pigs thereby allowing more flexibility to model the observed variance-covariance structure. Also, algebraically, the age required for each pig to reach a specific BW can be predicted. The CF gilts had slightly greater SD in BW at 153 and 174 d of age (9.0 and 10.0 kg) than the AIAO gilts (8.5 and 9.0 kg). However, the SD in predicted days of age required to achieve 110 kg was greater for CF gilts (19.3 vs. 11.3 d). These data demonstrate an improved fit of the two random effects model in comparison to the single random effects model.

**Key Words:** Mixed Effects Model, Nonlinear Growth Functions, Pig Growth

**107 Evaluation of biases in predicting fat-free lean mass of pigs fed ractopamine.** A. P. Schinckel\*, C. T. Herr, J. C. Forrest, B. T. Richert, and M. E. Einstein, *Purdue University; West Lafayette, IN.*

Barrows (BW  $69.6 \pm 4.0$  kg) were allotted by weight to evaluate the effects of dietary lysine levels while feeding ractopamine (RAC) on carcass composition and growth. Treatments (TRT) 1 and 2 were fed throughout the six-week trial, while TRT 3 changed weekly. Treatments were as follows: 1) 16% CP, .82% lys control diet; 2) 16% CP diet, .82% lys; 3) a phase fed diet sequence, 18% CP, 1.08% lys during wk 1 and 4, 20% CP, 1.22% lys during wk 2 and 3, 16% CP, .94% lys during wk 5, and a 16% CP diet .82% lys during wk 6. All diets for TRT 2 and 3 contained 20 ppm RAC. The four lean cuts from the right side of the carcasses ( $n = 15$  per TRT) were dissected into lean and fat tissue. The other cuts soft tissue was collected from the jowl, ribs, and belly. Proximate analyses were completed on these three tissue pools and a sample of fat tissue from the other cut soft tissue to determine fat-free lean mass (FFLN). Prediction equations were developed for FFLN. Independent variables included carcass weight (CW), last rib midline fat depth (BFLR), 10th rib fat depth (FD), and 10th rib loin muscle area (LMA). Live measurements included ultrasonic 10th rib fat depth (UFD) and loin muscle area (ULMA). Also, dissected ham lean (HL) and loin lean (LL) were

considered as independent variables. The mean residual values for the three TRT were evaluated as a measure bias. The FFLN was different ( $P < 0.01$ ) for the RAC TRT (39.4, 42.4, and 46.5.3 kg). The prediction equations had significant TRT biases. The FFLN of TRT 1 pigs were overpredicted and TRT 3 pigs under predicted. Prediction equations underestimate the FFLN of pigs fed RAC with high lysine diets.

Equation	R <sup>2</sup>	RSD, kg	Mean residual value	Probability
CW, BFLR	0.49	3.11	-2.58	0.31
CW, FD, LMA	0.62	2.55	-1.65	0.03
BW, UFD, ULMA	0.59	2.61	-1.67	-0.09
CW, FD, LL	0.74	2.15	-1.29	-0.02
CW, FD, HL	0.75	2.06	-0.56	-0.62
CW, FD, HL, LL	0.84	1.66	-0.39	-0.54

**Key Words:** Pigs, Carcass Composition, Ractopamine

**108 Effect of post-weaning growth rate, as affected by diet and floor space, on pig growth to slaughter in a wean-to-finish system.** B. F. Wolter\*<sup>1</sup>, M. Ellis<sup>1</sup>, S. E. Curtis<sup>1</sup>, B. P. Corrigan<sup>1</sup>, J. M. DeDecker<sup>1</sup>, E. N. Parr<sup>2</sup>, and D. M. Webel<sup>2</sup>, <sup>1</sup>University of Illinois, Urbana, <sup>2</sup>United Feeds, Sheridan, IN.

The objective was to study the effect of early post-weaning growth rate, as affected by diet and floor space, on subsequent growth to slaughter in a wean-to-finish system. Pigs ( $n = 1,728$ ) were used in a randomized block design with a 2 X 2 factorial arrangement of treatments: 1) diet (Complex vs Simple) and 2) floor space (Unrestricted vs Restricted). Treatments were imposed the first 8 wk post-weaning (Period 1) and growth was measured from weaning (5.0 0.01 kg BW; 17 d of age) to 23 wk post-weaning. The Simple treatment consisted of corn-soy based diets with minimal milk products, processed cereals, and animal protein-based ingredients compared to Complex. Floor- and feeder-space were 0.63 m<sup>2</sup> and 4 cm and 0.21 m<sup>2</sup> and 2 cm per pig, respectively, for Unrestricted and Restricted. From end of wk 8 to end of wk 23 (Period 2), pigs on all treatments had the same floor- and feeder-spaces and were fed a common diet program. There were no treatment interactions ( $P > 0.05$ ). In Period 1, pigs assigned to the Simple diet program had similar ADFI (639 vs 650 5.4 g;  $P > 0.05$ ), but reduced ADG (408 vs 424 3.8 g;  $P < 0.01$ ), gain:feed (G/F; 0.64 vs 0.65 0.002;  $P < 0.001$ ), and were lighter (2.8%;  $P < 0.01$ ) than those on Complex. In Period 2, growth was not affected ( $P > 0.05$ ) by previous diet program, and pig BW was similar (114.7 vs 115.0 0.50 kg;  $P > 0.05$ ) at the end of wk 23. Pigs kept at Restricted compared to Unrestricted space were lighter at end of wk 8 (6.5%;  $P < 0.001$ ), and had lower ADG (398 vs 434 3.8 g;  $P < 0.001$ ), ADFI (621 vs 668 5.4 g;  $P < 0.001$ ), and G/F (0.64 vs 0.65 0.002;  $P < 0.01$ ) in Period 1. However, Restricted pigs had higher ADFI (2215 vs 2261 12.0 g;  $P < 0.01$ ) and tended to have greater ADG (820 vs 836 5.6 g;  $P = 0.06$ ), but similar ( $P > 0.05$ ) G/F compared to Unrestricted in Period 2. Pig BW were similar (114.5 vs 115.2 0.50 kg;  $P > 0.05$ ) between space treatments at end of wk 23. Mortality and morbidity and backfat and loin depths were not influenced ( $P > 0.05$ ) by either diet program or space. Both the simple diet program and reduced space allowance used in the early period post-weaning resulted in reduced pig growth rate, but, early growth rate had little impact on pig BW or carcass measures at wk 23 post-weaning.

**Key Words:** Pigs, Diet Complexity, Floor Space

## Nonruminant Nutrition

**109 Effect of alpha-1,6-galactosidase, beta-1,4-mannanase, and beta-1,4-mannosidase on lactation performance in primiparous sows.** S. W. Kim\*, *Texas Tech University.*

Soybean meal contains 5.6%  $\alpha$ -galactoside and 1.2%  $\beta$ -galactomannans that pigs can not utilize because of they lack appropriate enzymes, resulting in gas production. Twenty two primiparous sows (Newsham) were used to test a hypothesis that dietary supplementation of an enzyme mixture (mainly composed of  $\alpha$ -1,6-galactosidase,  $\beta$ -1,4-mannanase, and  $\beta$ -1,4-mannosidase) reduces body weight loss and improves overall performance during lactation. On d 109 of gestation, sows were moved to farrowing crate. Immediately after farrowing (within 24

h), all sows and litters were weighed. Two sows with similar farrowing body weight were grouped and randomly allotted to one of two dietary treatments within a group. Sows in the control group were fed a diet containing 28% soybean meal and the enzyme was added at the level of 0.1% replacing corn. Within 48 h, litter size was standardized to 9 pigs by cross-fostering. Feed intakes of sows were measured individually on a daily basis. All the sows and litters were weighed on d 7, 14, and 21 after farrowing and all the litters were weaned on d 21. After weaning, sows were moved to gestation stalls and days return to estrus was recorded. At farrowing, sows from both treatments had the same body weight. However after a 21-d lactation, body weight loss from control group (12.8 kg) was greater ( $P < 0.05$ ) than that from enzyme group

**106 The use of nonlinear mixed models for swine growth.** A. P. Schinckel\* and B. A. Craig, *Purdue University, West Lafayette, IN.*

Alternative versions of a three-parameter nonlinear growth function (Bridges, 1986;  $BW_{i,t} = C(1 - \exp(-M t^A)) + \text{birthweight} + e_{i,t}$ , where  $t$  is days of age for the  $i$ th pig) were evaluated on two groups of gilts. The gilts were randomly assigned to be reared under all-in, all-out (AIAO,  $n = 96$ ) or continuous flow management (CF,  $n = 96$ ). The fixed effects version assumes the BW of each pig deviates from the BW growth function and that these deviations (i.e., residuals) are independent with constant variance. Empirically, these assumptions are not reasonable. As an alternative, we propose the use of random effects and investigate both one and two random effect models. The inclusion of random effects provides a flexible method to better reproduce the underlying variance-covariance structure of the serial live weights while still assuming the residuals are independent with constant variance. These models are also easily adaptable to stochastic modeling. For these data, the AIC (Akaike's Information Criteria) values for the fixed effects model were 2176 and 4116 for the AIAO and CF gilts. By allowing the mature body weight to vary pig to pig (i.e.,  $C + c_i$ ) the AIC values are reduced to 1904 and 3633 respectively, and the RSD's, the standard errors of the  $M$  and  $A$  parameters were reduced by over 50%. The addition of a second random effect for  $M$  (i.e.,  $M + m_i$ ) further reduced the AIC values (1883, 3568 for AIAO and CF) and the RSD's. The inclusion of the second random effect accounts for different patterns of growth between pigs thereby allowing more flexibility to model the observed variance-covariance structure. Also, algebraically, the age required for each pig to reach a specific BW can be predicted. The CF gilts had slightly greater SD in BW at 153 and 174 d of age (9.0 and 10.0 kg) than the AIAO gilts (8.5 and 9.0 kg). However, the SD in predicted days of age required to achieve 110 kg was greater for CF gilts (19.3 vs. 11.3 d). These data demonstrate an improved fit of the two random effects model in comparison to the single random effects model.

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Barrows (BW  $69.6 \pm 4.0$  kg) were allotted by weight to evaluate the effects of dietary lysine levels while feeding ractopamine (RAC) on carcass composition and growth. Treatments (TRT) 1 and 2 were fed throughout the six-week trial, while TRT 3 changed weekly. Treatments were as follows: 1) 16% CP, .82% lys control diet; 2) 16% CP diet, .82% lys; 3) a phase fed diet sequence, 18% CP, 1.08% lys during wk 1 and 4, 20% CP, 1.22% lys during wk 2 and 3, 16% CP, .94% lys during wk 5, and a 16% CP diet .82% lys during wk 6. All diets for TRT 2 and 3 contained 20 ppm RAC. The four lean cuts from the right side of the carcasses ( $n = 15$  per TRT) were dissected into lean and fat tissue. The other cuts soft tissue was collected from the jowl, ribs, and belly. Proximate analyses were completed on these three tissue pools and a sample of fat tissue from the other cut soft tissue to determine fat-free lean mass (FFLN). Prediction equations were developed for FFLN. Independent variables included carcass weight (CW), last rib midline fat depth (BFLR), 10th rib fat depth (FD), and 10th rib loin muscle area (LMA). Live measurements included ultrasonic 10th rib fat depth (UFD) and loin muscle area (ULMA). Also, dissected ham lean (HL) and loin lean (LL) were

considered as independent variables. The mean residual values for the three TRT were evaluated as a measure bias. The FFLN was different ( $P < 0.01$ ) for the RAC TRT (39.4, 42.4, and 46.5.3 kg). The prediction equations had significant TRT biases. The FFLN of TRT 1 pigs were overpredicted and TRT 3 pigs under predicted. Prediction equations underestimate the FFLN of pigs fed RAC with high lysine diets.

Equation	R <sup>2</sup>	RSD, kg	Mean residual value	Probability
CW, BFLR	0.49	3.11	-2.58	0.31
CW, FD, LMA	0.62	2.55	-1.65	0.03
BW, UFD, ULMA	0.59	2.61	-1.67	-0.09
CW, FD, LL	0.74	2.15	-1.29	-0.02
CW, FD, HL	0.75	2.06	-0.56	-0.62
CW, FD, HL, LL	0.84	1.66	-0.39	-0.54

**Key Words:** Pigs, Carcass Composition, Ractopamine

**108 Effect of post-weaning growth rate, as affected by diet and floor space, on pig growth to slaughter in a wean-to-finish system.** B. F. Wolter\*<sup>1</sup>, M. Ellis<sup>1</sup>, S. E. Curtis<sup>1</sup>, B. P. Corrigan<sup>1</sup>, J. M. DeDecker<sup>1</sup>, E. N. Parr<sup>2</sup>, and D. M. Webel<sup>2</sup>, <sup>1</sup>University of Illinois, Urbana, <sup>2</sup>United Feeds, Sheridan, IN.

The objective was to study the effect of early post-weaning growth rate, as affected by diet and floor space, on subsequent growth to slaughter in a wean-to-finish system. Pigs ( $n = 1,728$ ) were used in a randomized block design with a 2 X 2 factorial arrangement of treatments: 1) diet (Complex vs Simple) and 2) floor space (Unrestricted vs Restricted). Treatments were imposed the first 8 wk post-weaning (Period 1) and growth was measured from weaning (5.0 0.01 kg BW; 17 d of age) to 23 wk post-weaning. The Simple treatment consisted of corn-soy based diets with minimal milk products, processed cereals, and animal protein-based ingredients compared to Complex. Floor- and feeder-space were 0.63 m<sup>2</sup> and 4 cm and 0.21 m<sup>2</sup> and 2 cm per pig, respectively, for Unrestricted and Restricted. From end of wk 8 to end of wk 23 (Period 2), pigs on all treatments had the same floor- and feeder-spaces and were fed a common diet program. There were no treatment interactions ( $P > 0.05$ ). In Period 1, pigs assigned to the Simple diet program had similar ADFI (639 vs 650 5.4 g;  $P > 0.05$ ), but reduced ADG (408 vs 424 3.8 g;  $P < 0.01$ ), gain:feed (G/F; 0.64 vs 0.65 0.002;  $P < 0.001$ ), and were lighter (2.8%;  $P < 0.01$ ) than those on Complex. In Period 2, growth was not affected ( $P > 0.05$ ) by previous diet program, and pig BW was similar (114.7 vs 115.0 0.50 kg;  $P > 0.05$ ) at the end of wk 23. Pigs kept at Restricted compared to Unrestricted space were lighter at end of wk 8 (6.5%;  $P < 0.001$ ), and had lower ADG (398 vs 434 3.8 g;  $P < 0.001$ ), ADFI (621 vs 668 5.4 g;  $P < 0.001$ ), and G/F (0.64 vs 0.65 0.002;  $P < 0.01$ ) in Period 1. However, Restricted pigs had higher ADFI (2215 vs 2261 12.0 g;  $P < 0.01$ ) and tended to have greater ADG (820 vs 836 5.6 g;  $P = 0.06$ ), but similar ( $P > 0.05$ ) G/F compared to Unrestricted in Period 2. Pig BW were similar (114.5 vs 115.2 0.50 kg;  $P > 0.05$ ) between space treatments at end of wk 23. Mortality and morbidity and backfat and loin depths were not influenced ( $P > 0.05$ ) by either diet program or space. Both the simple diet program and reduced space allowance used in the early period post-weaning resulted in reduced pig growth rate, but, early growth rate had little impact on pig BW or carcass measures at wk 23 post-weaning.

**Key Words:** Pigs, Diet Complexity, Floor Space

## Nonruminant Nutrition

**109 Effect of alpha-1,6-galactosidase, beta-1,4-mannanase, and beta-1,4-mannosidase on lactation performance in primiparous sows.** S. W. Kim\*, *Texas Tech University.*

Soybean meal contains 5.6%  $\alpha$ -galactoside and 1.2%  $\beta$ -galactomannans that pigs can not utilize because of they lack appropriate enzymes, resulting in gas production. Twenty two primiparous sows (Newsham) were used to test a hypothesis that dietary supplementation of an enzyme mixture (mainly composed of  $\alpha$ -1,6-galactosidase,  $\beta$ -1,4-mannanase, and  $\beta$ -1,4-mannosidase) reduces body weight loss and improves overall performance during lactation. On d 109 of gestation, sows were moved to farrowing crate. Immediately after farrowing (within 24

h), all sows and litters were weighed. Two sows with similar farrowing body weight were grouped and randomly allotted to one of two dietary treatments within a group. Sows in the control group were fed a diet containing 28% soybean meal and the enzyme was added at the level of 0.1% replacing corn. Within 48 h, litter size was standardized to 9 pigs by cross-fostering. Feed intakes of sows were measured individually on a daily basis. All the sows and litters were weighed on d 7, 14, and 21 after farrowing and all the litters were weaned on d 21. After weaning, sows were moved to gestation stalls and days return to estrus was recorded. At farrowing, sows from both treatments had the same body weight. However after a 21-d lactation, body weight loss from control group (12.8 kg) was greater ( $P < 0.05$ ) than that from enzyme group

(2.1 kg). There was no difference in daily feed intake between treatments. Litter weight gain was not different between treatments. Days return to estrus was smaller ( $P < 0.05$ ) for the enzyme treatment (4.68 d) than control treatment (5.94 d). Two sows from each treatment did not return to estrus until d 25 post weaning. Supplementing enzyme improved sow lactation performance by reducing body weight loss and days return to estrus whereas it did not improve litter weight gain and sows' feed intake.

**Key Words:** Lactation, Sows, Enzyme

**110 Effect of added soybean oil or full-fat canola meal on sow and litter performance.** B.S. Zimprich\*, T.E. Socha, and R.L. Harrold, *North Dakota State University*.

Seventy-six sows were used to evaluate sow and litter performance, sow body condition, days to estrous, and milk composition when sunflower oil (SA) or canola meal (CA) were added to a control (C) diet of corn and soybean meal. Sows were randomly assigned to a diet at day 100 of gestation. Sows were measured for body condition by using real-time ultrasound on days 100 of gestation, day of farrowing, day 7, and at weaning. The sows were also weighed at these times. Milk samples were randomly taken from three sows per treatment per farrowing. Milk samples were analyzed for solids, protein, and fat at day 0, and 14. Litter weights were taken on days 0, 2, 7, and weaning. SA sows returned to estrous earlier than C sows (4.94 vs. 5.57;  $P<.09$ ). Sows on diet C lost less weight than CA sows between day 100 pre-farrow and farrowing (-6.26 vs. -11.65 kg;  $P<.01$ ). Sows on the SA and CA diets weaned heavier litters than the sows on diet C (51.36, 52.02 vs. 45.25 kg;  $P<.03$ ). Sows on diet C ate more feed pre-farrow than sows on diet CA (39.5 vs. 35.5 kg;  $P<.001$ ). Sows on diet SA ate more than sows on diets C and CA between farrowing, and day 7 (36.42 vs. 31.82 and 31.75 kg;  $P<.06$ ). Between day 7 and weaning sows on diets CA and SA ate more than the sows on diet C (59.71, 54.77 vs. 47.24 kg;  $P<.0008$ ). Overall feed intake data indicated that sows on diet SA consumed more than sows on diet C (129.59 vs. 118.64 kg;  $P<.03$ ). Milk composition on day zero showed no differences between treatments, however, sows on SA had a higher fat content than sows on diets C and CA at day 14 (9.33 vs. 7.02, and 8.01%;  $P<.004$ ). There were no differences in survival rate between treatments (86.4, 90.3, and 88.9%). Backfat on the sows of all treatments between days 100 pre-farrow and farrowing decreased 1.78 mm. Supplementing a corn soybean meal ration with sunflower oil or canola meal was beneficial.

**Key Words:** Full-Fat Canola, Sow Performance, Milk Composition

**111 Effects of dietary L-carnitine and chromium picolinate on sow reproductive performance.** D. E. Real\*<sup>1</sup>, J. L. Nelsens<sup>1</sup>, M. D. Tokach<sup>1</sup>, R. D. Goodband<sup>1</sup>, S. S. Dritz<sup>1</sup>, and K. Q. Owen<sup>2</sup>, <sup>1</sup>*Kansas State University, Manhattan*, <sup>2</sup>*Lonza Inc., Fairlawn, NJ*.

A total of 599 sows were used to determine the effects of dietary L-carnitine and/or chromium picolinate (Cr) on reproductive performance. Experimental treatments were arranged in a 2 X 2 factorial with main effects of L-carnitine (0 or 50 mg/kg) and Cr picolinate (0 or 200 mg/kg). Starting on the first day of breeding, all sows were provided a daily top dress containing the dietary treatments along with the normal diets. Dietary treatments were provided through the initial gestation, lactation, and through a second gestation period (2 parities). During the first parity, there was a carnitine X chromium interaction ( $P < 0.01$ ) for first service farrowing rate with values of 82.9, 91.9, 95.5, and 92.2% for control, carnitine, Cr, and both, respectively. No differences ( $P > 0.05$ ) were observed in number of pigs born alive, still born, mummies, or total born in the first parity. Added dietary L-carnitine decreased ( $P < 0.05$ ) wean-to-estrus interval, and tended to increase ( $P < 0.08$ ) the number of sows in estrus by d 7. In the second parity, a tendency ( $P < 0.08$ ) for a carnitine X chromium interaction was found for first service farrowing rate. Adding carnitine and chromium together in the diet increased first service farrowing rate compared to the control or either product alone. Because of the change in wean-to-estrus interval and farrowing rate, feeding additional dietary carnitine and chromium increased ( $P < 0.04$ ) the percentage of sows that were farrowed in parity 2. When calculating the total number of pigs born and born live based on all sows that were started on test, carnitine and chromium additively increased ( $P < 0.02$ ) the number of pigs born and born alive (Total born: 15.3, 18.4, 18.8, and 19.7; born live: 13.9, 16.3, 16.2, and 17.0

for control, carnitine, Cr, and both, respectively). In conclusion, adding dietary carnitine and chromium improved wean-to-estrus interval and farrowing rate and, thus, total pigs born live over two parities.

**Key Words:** Sows, Carnitine, Chromium

**112 A regional evaluation of chromium tripicolinate supplementation in sows.** M. D. Lindemann\*, S. D. Carter, L. I. Chiba, C. R. Dove, and L. L. Southern, *S-288 Regional Research Committee on Nutrition and Management of Swine for Increased Reproduction*.

Supplementation of sows with chromium tripicolinate has provided promising increases in litter size. However, varied levels of supplementation have not been examined with sows. This study was conducted to evaluate multiple levels of supplementation across a variety of conditions at five universities. Supplemental Cr levels of 0, 200, 600, and 1000 ppb from chromium tripicolinate were used. The rate of 600 ppb provides the mature animal with similar Cr supply per kg BW as a growing pig fed 200 ppb; the rate of 1000 ppb is 5X to the standard rate of 200 ppb. Participants were required to use at least three of the four levels, including 0 and 200 ppb. A total of 285 gilts and sows were allotted to treatment on the day of breeding. A common corn-soy diet formulation was used that met or exceeded NRC (1988) requirement estimates for reproduction. Only those sows completing at least two parities were considered in the data analysis. A total of 439 litters (litter was the experimental unit) were included in the analysis. The model included terms for station, treatment, study parity, and all possible interactions. There were significant station effects for all measured responses but no meaningful station X treatment interactions. With regard to litter size, the response of primary interest, a tendency for an increase in total pigs born/litter with increasing Cr supplementation was observed (10.17, 10.86, 11.09, and 10.53, respectively;  $P=.14$ ). The litter size responses in live born (9.27, 9.59, 10.12, 9.71) and weaned (8.30, 8.47, 9.00, and 8.83) followed the same pattern but were not significant. In summation, supplementation of 200 ppb Cr from chromium tripicolinate yielded mean litter size increases similar to published literature. Numerical increases in litter size beyond that observed at 200 ppb may suggest merit to continued research to evaluate higher supplementation rates. Levels of 5X current supplementation rates, though they were fed for up to three parities in sows, were not detrimental.

**Key Words:** Sows, Chromium, Litter Size

**113 Comparison of International Protein Corporation 740 and Super Select<sup>TM</sup> Menhaden fish meals in nursery pig diets.** M. G. Young\*, M. D. Tokach, R. D. Goodband, J. L. Nelsens, S. S. Dritz, and M. Cici<sup>1</sup>, *Kansas State University, Manhattan*, <sup>1</sup>*International Protein Corporation, St. Paul, MN*.

One hundred and seventy five pigs (6.42 kg and 17 ± 2 d) were used in a 21 d growth assay to compare two menhaden fish meals (IPC 740, International Proteins Corp, St. Paul, MN or Special Select<sup>TM</sup>, Omega Proteins, Hammond, LA) on growth performance of nursery pigs. All pigs were fed a common diet for four days after weaning before allotment to dietary treatments. Dietary treatments were fed in meal form. Diets were formulated to contain 1.40% lysine, 0.84% Ca and 0.49% available P. In addition, 10% dried whey, 3% soybean oil and 0.13% L-lysine HCl was added to all diets. There were 5 experimental diets with a control diet (no added fish meal) and 2.5 and 5% fish meal from the two sources (IPC or Omega). From d 0 to 14, ADG improved linearly ( $P<0.05$ ) with increasing fish meal from either source (see Table below). No differences in performance were observed between the two fish meal sources. During the third week (d 14 to 21), there was no benefit to adding fish meal to the diet. For the overall trial, there were no differences in ADG, ADFI, or gain/feed. The best response to adding fish meal to the diet was obtained for the first 14 d of the test, coinciding with the time when fish meal would be fed in commercial production. These results indicate that IPC 740 and Special Select<sup>TM</sup> can be used interchangeably as Menhaden fish meal sources in starter diet formulation.

Fish Meal Source:	IPC		Special Select <sup>TM</sup>		
Level, %:	0	2.5	5	2.5	5
ADG, g	193	217	228	203	227
Gain/Feed	0.67	0.67	0.73	0.68	0.70

**Key Words:** Weanling Pig, Fish Meal

**114 Comparison of yellow dent and NutriDense corn hybrids for nursery pig diets.** C.W. Hastad\*, M.D. Tokach, J.L. Nelssen, R.D. Goodband, S.S. Dritz, and C.M. Peter<sup>1</sup>, *Kansas State University, Manhattan Kansas*, <sup>1</sup>*Exseed Genetics L.L.C. Owensboro, Kentucky*.

A total of 315 nursery pigs (BW = 15.2 kg) were used in a 21-d growth assay to determine the relative energy value of both NutriDense (ND) and NutriDense Low Phytate (NDLP) corn compared to normal yellow dent (YD) corn. The ND is a high-protein, high-oil variety; and NDLP is a high-protein, high-oil, low-phytate variety. Pigs were weighed and allotted to one of nine treatments with five pigs per pen and seven pens per treatment. Dietary treatments were arranged in a 3×3 factorial design, with corn source representing one factor (YD, ND, and NDLP) and supplemental fat level representing the other factor (0, 3, or 6%). No corn source × fat level interactions ( $P > 0.10$ ) were observed for any of the performance criteria. Performance values for YD, ND, and NDLP were 750, 734, and 738 g/d for ADG and 0.645, 0.661, and 0.656 for gain/feed (G/F), respectively. No differences ( $P > 0.11$ ) in ADG were observed among corn sources. Feeding pigs diets containing either ND or NDLP corn, however, reduced ADFI ( $P < 0.02$ ) and improved G/F ( $P < 0.05$ ) compared to those fed YD corn. Increasing dietary fat levels produced linear improvements in both ADG (726, 748, and 748 g/d;  $P < 0.04$ ) and G/F (0.625, 0.656, and 0.681;  $P < 0.001$ ), and reduced ADFI ( $P < 0.01$ ). These data indicate the ME values for ND and NDLP corn are 5 and 3% higher, respectively, than for YD corn. These data are in agreement with the data of Peter et al. (2001; JAS 79: suppl. 2; abstract 236) wherein ND and NDLP corns were reported to contain 6.5 and 4% more ME, respectively, than YD corn, and the ME content of NDLP is 2% lower than that of ND corn. The lack of interaction between corn source and fat level also indicates that higher energy diets can be achieved through the use of ND or NDLP corn and fat to achieve further improvements in feed efficiency.

**Key Words:** Pigs, Corn Hybrids, Metabolizable Energy

**115 Effect of pellet hardness on growth performance of weaned pigs.** I. Mavromichalis<sup>\*1</sup>, D. R. Cook<sup>2</sup>, M. M. Ward<sup>2</sup>, and N. D. Paton<sup>2</sup>, <sup>1</sup>*SCA Nutrition USA, Marion IA*, <sup>2</sup>*Akey, Inc., Lewisburg OH*.

Pellet hardness is closely associated with pellet durability, a desirable trait in nursery diets. Field observations, however, suggest weaned pigs exhibit an aversion to hard pellets by reducing consumption. We conducted two experiments to determine the effects of pellet hardness on growth performance during the postweaning period. In Exp. 1, 440 weaned pigs (5.4 kg; 18 d), in 10 replicates, were used to determine the effects of soft vs hard pellets on growth performance during an 11-d period. Pellet hardness was manipulated by replacing raw starch (soft) with gelatinized starch (hard). Diets were conditioned for 30 s at 59°C before pelleting (2.4 mm). Starch processing did not affect dietary energy use, as evidenced by comparable feed efficiency between treatments. Feed intake (-13%) and weight gain (-11%), however, were markedly reduced ( $P < 0.02$ ) by increased pellet hardness. In Exp. 2, 880 weaned pigs (4.9 kg; 18 d), in 10 replicates, were used to determine the effects of increasing pellet hardness on growth performance during a 14-d period. Pellet hardness was progressively increased by replacing 0, 33, 66, and 100% of the raw starch (25%) in the basal diet with gelatinized starch. Pellet durability index was 67, 93, 92, and 97% for the four experimental diets. Feed manufacturing was as in Exp. 1. In agreement with Exp. 1, feed efficiency was not affected by pellet hardness, indicating that pellet quality and not starch processing was responsible for differences in growth performance. Indeed, feed intake ( $P < 0.09$ ) decreased slightly (218, 214, 209, 197 g/d) in a linear pattern with increasing pellet hardness, whereas numerical differences in weight gain (203, 197, 192, and 181 g/d) were not significant. In conclusion, it appears increasing pellet hardness in diets for young pigs reduces feed intake during the first two weeks postweaning.

**Key Words:** Nursery Pigs, Pellet Hardness, Pellet Quality

**116 Effects of soybean meal particle size on growth performance of nursery pigs.** K. R. Lawrence, C. W. Hastad, R. D. Goodband, M. D. Tokach, J. L. Nelssen, S. S. Dritz, and M. J. Webster, *Kansas State University, Manhattan, KS*.

The objective of this study was to evaluate the influence of reducing particle size of extruded-expelled soybean meal and solvent extracted soybean meal on growth performance of nursery pigs. A total of 360 pigs were used in two 21-d growth assays with six pigs per pen and ten pens per treatment. Pigs were fed the same SEW diet for 7 d after weaning, followed by a common Phase 2 diet from d 7 to 14. On d 14, all pigs were weighed and allotted to one of three dietary treatments. All diets contained 61.9% corn and 34.4% soybean meal. Diets were formulated to 1.2% total lysine, 0.78% Ca, and 0.40% available P. In Exp. 1, pigs were fed diets containing a single lot of extruded-expelled soybean meal ground to 965, 742, or 639 microns, which resulted in whole diet particle sizes of 728, 719, and 697 microns. In Exp. 2, pigs were fed a diet containing one lot of solvent extracted soybean meal ground to 1226, 797, or 444 microns, which resulted in whole diet particle sizes of 732, 681, and 629 microns, respectively. In Exp. 1, reducing particle size of extruded-expelled soybean meal had no effect ( $P > 0.18$ ) on ADG (541, 537, and 540 g/d) and feed efficiency (G/F; .61, .61, .63) for pigs fed diets containing 965, 742, and 639 micron extruded-expelled soybean meal, respectively. In Exp. 2, reducing particle size of solvent extracted soybean meal had no effect ( $P > 0.61$ ) on ADG (483, 487, 481g/d) and G:F (0.66, 0.66, 0.65) for pigs fed diets containing 1226, 797, or 444 micron solvent extracted soybean meal, respectively. These results suggest that soybean meal particle size ranging from 1226 to 440 microns does not affect nursery pig growth performance.

**Key Words:** Pigs, Particle Size, Soybean Meal

**117 Impact of stocking density/group size on the response to changes in dietary energy content by weanling pigs from 25 to 53 days of age.** C.L. Levesque<sup>1,2</sup>, J.F. Patience<sup>\*1</sup>, E. Beltranena<sup>1</sup>, and R.T. Zijlstra<sup>1</sup>, <sup>1</sup>*Prairie Swine Centre Inc.*, <sup>2</sup>*University of Saskatchewan, Saskatoon, SK, Canada*.

The primary limitation to growth in the young pig is gut capacity; however, increasing dietary digestible energy (DE) concentration did not previously result in improved pig performance to 56 d of age. The absence of response may have been due to lack of stressors, such as crowding. This experiment evaluated the interaction of dietary DE content and stocking density/group size (i.e. crowding) on weanling pig performance. A total of 600 pigs weaned at 19 d of age were assigned within 3 replicate groups to one of 10 treatments arranged in a 2 X 5 factorial with 2 stocking densities/group sizes ( $\text{m}^2/\text{kg BW}^{.667}$ ; pigs per pen): LSD (0.0471:16) or HSD (0.0314:24) and 5 dietary DE levels (Mcal/kg): VLOW (3.19); LOW (3.33); MID (3.47); HIGH (3.61) or VHIG (3.75). Diet DE content was altered by changing the relative concentrations of low (barley) and high (wheat, canola oil) energy ingredients. Pigs received experimental diets in mash form from 25 to 53 d of age. Body weight (BW) and feed disappearance were measured weekly. At 53 d of age, pig BW (20.15 kg 0.06 SEM) was not affected by diet or stocking density ( $P > 0.08$ ). ADFI decreased ( $P < 0.05$ ) and feed efficiency improved ( $P < 0.001$ ) with increasing dietary DE level. Overall, pig ADG did not improve ( $P > 0.10$ ) with dietary DE level, regardless of crowding. Daily DE intake was higher in LSD ( $P = 0.05$ ) versus HSD. At LSD, daily DE intake was greatest in pigs on the HIGH diet. At HSD, daily DE intake was lowest in pigs on the VLOW diet ( $P < 0.05$ ). Pigs on VLOW and HSD were lightest at 53 d of age compared to other treatment groups ( $P < 0.05$ ). The weanling pig was able to compensate for reduced dietary DE through increased feed intake; however, when crowded and fed very low dietary DE levels, the young pig's ability to compensate may be exceeded. In conclusion, growth limitations in the weanling pig may not be overcome simply by increasing dietary DE content.

**Key Words:** Digestible Energy, Pig, Stocking Density

**118 Effects of sorting and penning pigs by BW vs. mixing pigs of different BW on post weaning growth performance.** D. R. Cook, M. M. Ward, and N. D. Paton\*, *Akey Inc. Lewisburg, OH*.

In Exp. 1, 880 pigs (18 d old;  $0.25 \text{ m}^2/\text{pig}$ ) were weighed individually and allotted to one of 5 pre-determined weight classes: A (6.97 kg), B



(5.74 kg), C (5.18 kg), D (4.66 kg) and E (3.93 kg). Weight classes were based on historical distribution of pig weights in the facility. Pigs were allotted to one of two treatments: same weight (SW) with 22 pigs of the same weight class in a pen (22-A, 22-B, 22-C, 22-D or 22-E pigs) or mixed weights (MW) with 22 pigs from 5 different weight classes in a pen (4-A, 5-B, 5-C, 4-D and 4-E pigs). In SW pens, groups of 4 to 5 pigs were randomly allotted to arbitrary blocks to create an experimental unit of the same size as those present in MW pens. This allowed testing effect of treatment on BW and ADG coefficient of variation (C.V.). All pens received identical feed budgets. All pigs were individually weighed on d 0 and d 42 post-weaning. Pen weights and feed disappearance were collected on days 7, 14 and 21 post-weaning. There were no differences ( $P>.10$ ) in ADG, ADFI or G/F for pigs sorted by SW or MW. Initial weight and final weight were different among the 5 weight classes ( $P<.001$  and  $P<.01$ , respectively), but sorting method had no effect on BW or ADG C.V. ( $P>.10$ ). In Exp. 2, two groups of 880 pigs each were visually sorted into 5 weight classes and allotted to treatment as in Exp. 1. Pens in the SW treatment were budget fed according to BW. Pens in the MW treatment all received the average budget of the SW treatment. From d 0 to 45, pigs in the MW group had greater ADG ( $P<.01$ ) and ADFI ( $P<.01$ ) and were 0.53 kg heavier ( $P<.01$ ) at the end of 45 days versus the SW group. Based on a similar magnitude of BW difference between MW and SW pigs at the conclusion of each Exp., and the statistical significance of this response when 40 replications were used (Exp.2), we conclude that providing some degree of BW variation in pigs post weaning improves growth performance vs. attempting to equalize pig BW within a pen.

**Key Words:** Pigs, Sorting, Nursery

**119 Response of weaned pigs to increasing lysine:digestible energy ratio.** T. F. Oresanya<sup>\*1,2</sup>, J. F. Patience<sup>1</sup>, and A. D. Beaulieu<sup>1</sup>, <sup>1</sup>*Prairie Swine Centre, Inc., Saskatoon, Canada*, <sup>2</sup>*University of Saskatchewan, Saskatoon, Canada*.

Lean growth potential of young pigs may be limited due to gut capacity for feed intake. Amino acids, therefore, should be defined in relationship to dietary energy content. However, there is no agreement on the correct lysine:DE ratio for high performing pigs. This experiment was conducted to investigate the effect of lysine/digestible energy ratio (g/Mcal) on the performance of weaned pigs. A total of 240 weaned pigs (20 1.4 d; 6.5 0.9 kg) were blocked by weight per day of age within sex and randomly allocated to pens of 4 pigs each (2 barrows and 2 gilts) and to one of 10 dietary treatments in a 2 x 5 factorial arrangement with 3 replicates. Factors were low energy (LE, 3.4 Mcal DE/kg) or high energy (HE, 3.6 Mcal DE/kg) and 5 lysine/DE ratios (3.7, 4.0, 4.3, 4.6, and 4.9 g total lysine/Mcal DE). Digestible energy was increased by increasing the levels of high energy ingredients and supplementing canola oil; and the lysine:DE ratio was increased by varying the levels of high lysine ingredients and supplementing crystalline amino acids. Pigs were fed a commercial starter diet from weaning until 27 d of age when the feeding of the experimental diet was initiated for a 28 d period. Pigs' individual BW and pen feed disappearance were measured weekly. Average daily feed intake (ADFI) was not affected by lysine:DE but was affected by DE such that pigs on LE diets had higher ADFI than HE diets (858 vs. 824 g/d;  $P < 0.05$ ). Conversely, there was no effect of DE on ADG ( $P > 0.05$ ), but ADG was increased by increasing the lysine:DE ratio up to 4.6 g lysine/Mcal (linear, quadratic,  $P < 0.10$ ). Feed efficiency (G:F) was improved with the HE diets (0.626 vs. 0.656;  $P < 0.05$ ). The highest ADG over the 28 d period for pigs growing from 7.5 to 22.5 kg was observed at 4.9 and 4.6 g lysine/Mcal for the LE and HE diets, respectively. This corresponds to 1.66% total lysine for both diets.

**Key Words:** Piglets, Lysine, Digestible Energy

**120 Defining the tolerable level of ergot in weanling pig diets.** T. F. Oresanya<sup>1,2</sup>, J. F. Patience<sup>1</sup>, R. T. Zijlstra<sup>1</sup>, D. M. Middleton<sup>2</sup>, B. R. Blakley<sup>2</sup>, A. D. Beaulieu<sup>\*1</sup>, and D. A. Gillis<sup>1</sup>, <sup>1</sup>*Prairie Swine Centre, Inc., Saskatoon, Canada*, <sup>2</sup>*University of Saskatchewan, Saskatoon, Canada*.

Ergot-alkaloids may cause significant economic losses when ergot-contaminated grains or by-products are fed to pigs. This study investigated the effect of ergot alkaloids on performance and clinical signs of weanling pigs. A total of 192 weanling pigs (20.4 3.4 d; 6.9 1.3 kg) were randomly allotted to pens (2 gilts; 2 barrows) in 2 replicates.

Ground wheat ergot sclerotia (1880 mg alkaloid/kg) with ergocristine, ergotamine, ergosine, ergocryptine, and ergocornine constituting 40, 36, 11, 7, and 6%, respectively, were added on a weight basis to a basal diet (3.5 Mcal DE/kg and 1.35% total lysine) at 0.00 (control), 0.05, 0.10, 0.25, 0.50, and 1.00%. Thus, diets contained 0.00, 1.04, 2.07, 5.21, 10.41, and 20.82 mg alkaloid/kg, respectively. Pigs' BW and feed disappearance were measured weekly for 28 d. Nervous signs or cutaneous lesions associated with ergotoxicity were not observed. Average daily gain (ADG) was similar for diets that contained 0.00 to 2.07 mg alkaloid/kg but was depressed at 5.21 mg/kg and above (quadratic;  $P < 0.001$ ). The effects were most pronounced in wk 1 and 2 with pigs fed the 20.82 mg/kg diet gaining 82 and 38% less than control (211 vs. 39 g/d, and 432 vs. 269 g/d, wk 1 and 2, respectively), for a 37%-reduction over the 28 d (472 vs. 298 g/d). Also, ADFI was decreased (quadratic;  $P < 0.05$ ) for the entire period; however, ADFI was unaffected by alkaloids during the first two wk ( $P > 0.20$ ). Gain/feed was decreased by alkaloids (0.572 vs. 0.143, wk 1; 0.607 vs. 0.308, entire period; control vs. 20.82 mg/kg; quadratic  $P < 0.05$ ). Pig BW on d 28 was reduced by alkaloids (20.3 vs. 15.4 kg; control vs. 20.82 mg/kg; quadratic,  $P < 0.001$ ). From these results, the maximum level of alkaloids in weanling pig diets without adverse effects on ADG and feed efficiency was 2.31 mg alkaloid/kg based on the alkaloid content and profile of ergot sclerotia used in this study. This corresponds to 0.12 g ergot sclerotia per 100 g diet.

**Key Words:** Piglets, Ergot, Performance

**121 Tissue, sub-cellular and sub-mitochondrial location of lysine  $\alpha$ -ketoglutarate reductase in piglets.** N. J. Benevenga<sup>\*</sup>, L. G. Haas, and T.D. Crenshaw, *University of Wisconsin-Madison*.

Earlier work in rats (J. Nutr. 106:1089-1096, 1976) found lysine  $\alpha$ -ketoglutarate reductase activity in liver, kidney, pancreas and brain. Our work with rats showed the first two enzymes for lysine degradation (lysine  $\alpha$ -ketoglutarate reductase and saccharopine dehydrogenase) were located exclusively in the matrix of liver mitochondria (J. Nutr. 124:1215-1221, 1994). The total organ distribution of mitochondrial lysine oxidation in 2-5 kg piglets, using the liver as a reference base (percent of liver = total organ/total liver x 100 SD, n=2) was liver 100; heart, 29.0 23.3; kidney, 24.3 0.8; small intestine, 17.8 10.3; longissimus dorsi, 3.4 1.9; lung, 3.5 0.7; spleen, 0.2 0.1 and pancreas, 0.1 0.0. When the sub-cellular distribution of lysine oxidation was investigated in nine tissues, the only site of <sup>14</sup>CO<sub>2</sub> production from U-<sup>14</sup>C-L-lysine was mitochondria. In another study with 4 piglets, the sub-cellular distribution of the first enzyme in the saccharopine dependent pathway of lysine catabolism (lysine  $\alpha$ -ketoglutarate reductase) was measured in liver, kidney and heart. In all three tissues, the activity in mitochondria accounted for total tissue activity. The sub-mitochondrial location of an enzyme was identified by comparison to the location of marker enzymes. These enzymes, monoamine oxidase (outer membrane), cytochrome oxidase (inner membrane) and ornithine aminotransferase (matrix) allowed for identification of the sub-mitochondrial location of piglet liver lysine  $\alpha$ -ketoglutarate reductase. The distribution of lysine  $\alpha$ -ketoglutarate reductase was identical to ornithine aminotransferase indicating it is only located in the matrix of liver mitochondrion, an observation shown previously in rats. The sub-mitochondrial location of lysine  $\alpha$ -ketoglutarate reductase suggests a role for transport control of lysine catabolism and may account for the unique nutritional responses, conservation and delayed supplementation, shown in rats fed diets limiting in lysine.

**Key Words:** Pig, Lysine, Mitochondria

**122 Low phytate barley cultivars for growing pigs: Growth performance and bone strength.** T. L. Veum<sup>\*1</sup>, D. W. Bollinger<sup>1</sup>, D. R. Ledoux<sup>1</sup>, M. S. Carlson<sup>1</sup>, and V. Raboy<sup>2</sup>, <sup>1</sup>*University of Missouri, Columbia, MO*, <sup>2</sup>*USDA-ARS National Small Grain Germplasm Research Facility Aberdeen, ID*.

Crossbred barrows (n=45, average 9.5 kg BW) were fed individually to evaluate low phytate mutant barley cultivars compared to the normal Harrington check (HC) barley in a 4-wk experiment with growth performance and bone strength as the criteria. The barley cultivars were analyzed for nutrient content prior to diet formulation. Total P (tP) averaged 0.35% for the barley cultivars. Phytic acid P, as a % of tP, was determined for HC (66.7) and mutant (M) barley cultivars M422 (35.5), M635 (22.9), M955 (14.3), hull-less M422 (HM422, 35.3), and

SBM (61.4). Diets 1 to 4 were barley cultivars HC, M422, M635, and M955 without added inorganic P (iP). Diets 5 to 7 were the HC, M422, and M635 supplemented with iP to equal the calculated available P (aP, 29%) in M955. Diets 8 and 9 were HM422 and HM422+iP. Dried whey, blood cells, SBM and lactose were standardized in all diets. Pigs were killed on d 28 of the experiment, and the right radius (RB) and third metacarpal bones (MB) were removed. ANOVA included linear and quadratic contrasts for Diets 1 to 4 (HC, M422, M635 and M955) plus six other contrasts. There were linear increases ( $P < .05$ ) in ADG and bone breaking strength (MB and RB) with decreasing concentration of phytic acid in the barley cultivars. There were no growth performance or bone strength differences ( $P > .5$ ) between M955 and diets 5 to 7 containing iP to equal the aP in M955. The addition of iP to HC, M422 and HM422 increased ( $P < .05$ ) growth performance and bone strength compared to the same barley cultivar without iP. In conclusion, growth performance criteria and the breaking strength of the metacarpal and radius bones improved as phytic acid concentration in the mutant barley cultivars declined. When iP was added to equalize estimated aP in the diets there were no differences in the criteria measured, indicating that nutritional value was also equalized.

**Key Words:** Barley, Phytic Acid, Pigs

**123 Low phytate barley cultivars for growing pigs: Ca, P, and N utilization.** T. L. Veum<sup>\*1</sup>, D. W. Bollinger<sup>1</sup>, D. R. Ledoux<sup>1</sup>, M. S. Carlson<sup>1</sup>, and V. Raboy<sup>2</sup>, <sup>1</sup>University of Missouri, Columbia, MO, <sup>2</sup>USDA-ARS National Small Grain Germplasm Research Facility, Aberdeen, ID.

Crossbred barrows were fed individually to evaluate low phytate mutant barley cultivars compared to normal Harrington check (HC) barley in a 4-wk experiment (9 treatments with 5 pigs/treatment) with Ca, P, and N utilization and excretion as the criteria (Growth performance and bone strength are reported in a companion abstract). Estimated % available P (aP), calculated by subtracting % phytic acid P from % tP, was determined for HC (.12) and mutant (M) barley cultivars M422 (.20), M635 (.27), M955 (.30), hull-less M422 (HM422, .22), and SBM (.27). Diets 1 to 4 were barley cultivars HC, M422, M635, and M955 without added inorganic P (iP). Diets 5 to 7 were HC, M422, and M635 with added iP to equal the aP in M955. Diets 8 and 9 were HM422 and HM422+iP. Chromic oxide was added (.05%) to all diets. Fecal and total urine collections were made from d 22 to 26 of the experiment. ANOVA included linear and quadratic contrasts for Diets 1 to 4 (HC, M422, M635, and M955) plus six other contrasts. There were linear decreases ( $P < .01$ ) in fecal excretion (g/d) of Ca and P, and linear increases ( $P < .01$ ) in absorption and retention (g/d and %) of Ca and P with increasing concentrations of aP in the barley cultivars. Fecal excretion (g/d) of Ca and P was lower ( $P < .01$ ) and absorption and retention (g/d and %) of P was higher ( $P < .01$ ) for M955 than for the diets containing added iP to provide equal aP concentrations. The addition of iP to HC, M422, M635 and HM422 increased ( $P < .01$ ) the absorption and retention of P (g/d) compared to the same barley cultivar without iP. Fecal excretion (g/d and %) of N was lower ( $P < .05$ ) for M955 than for the diets containing added iP to equalize aP concentration. In conclusion, the excretion of Ca and P was reduced and the absorption and retention of Ca and P were increased as the phytic acid concentration in the mutant barley cultivars declined. The addition of iP to barley diets increased P excretion, absorption and retention.

**Key Words:** Barley, Phytic Acid, Pigs

**124 Effects of Fibrozyme and phytase enzymes on growing-finishing pig performance in field pea-canola meal supplemented diets.** D.G. Landblom<sup>\*1</sup>, R.L. Harrold<sup>2</sup>, W.W. Poland<sup>1</sup>, and K.A. Dawson<sup>3</sup>, <sup>1</sup>NDSU - Dickinson Research Extension Center, Dickinson, ND, <sup>2</sup>NDSU - Animal and Range Science Dept., Fargo, ND, <sup>3</sup>Alltech Biotechnology, Inc., Nicholasville, KY.

Supplemental phytase improves phosphorus availability and subsequent digestibility. Research with ruminants direct-fed protected fibrolytic enzymes has shown improved organic matter digestibility, growth performance in steers and milk production in dairy cattle. Field peas and canola meal have been proven to be complementing sources of protein and energy. The purpose of this study was to determine the potential for improved pig performance resulting from fibrozyme activity when

fed with and without phytase enzyme in field pea-canola meal supplemented corn-based growing-finishing diets. Allzyme phytase and fibrozyme were furnished by Alltech Biotechnology, Inc. Ninety (PIC - C22 x 356) barrows and gilts were assigned to dietary treatments: 1) Corn-SBM control, 2) Corn-Pea-Canola meal, 3) Corn-Pea-Canola Meal + fibrozyme, 4) Corn-Pea-Canola Meal + phytase, 5) Corn-Pea-Canola Meal + phytase + fibrozyme. The corn-SBM control diet was pelleted and all other diets were prepared in meal form. Compared to diets prepared in meal form, pigs receiving the pelleted corn-SBM control diet consumed less feed ( $P = .0001$ ), grew at the fastest rate ( $P = .001$ ), were more efficient ( $P = .001$ ), and had heavier hot carcass weight ( $P = .0001$ ). Diets with enzymes were formulated to contain 500 U/kg of phytase and 4000 IU/kg of fibrozyme. Correspondingly, in the presence of phytase, dietary available phosphorus requirement was reduced 0.1%. Growth performance and carcass characteristics among pigs receiving the corn-pea-canola control diet and the same diet with added phytase were similar. Fibrozyme addition in conjunction with phytase tended to improve ADG, improved gain to feed efficiency ( $P = .042$ ), and improved hot carcass weight ( $P = .046$ ). These data suggest fibrozyme-phytase enzyme addition can reduce supplemental phosphorus requirement, improve performance efficiency, and hot carcass weight.

**Key Words:** Peas and Canola Meal, Phytase, Fibrozyme

**125 Efficacy of dietary phosphorus (P) sources for growth based on available P equivalency.** T.S. Stahly<sup>\*</sup>, T.R. Lutz, and R.D. Clayton, Iowa State University, Ames, IA.

The efficacy of a unit of available P (AP) from 2 sources of P provided at varying degrees of P adequacy and during different stages of pig development was evaluated. A basal, corn-SBM mixture fortified to meet or exceed all nutrient needs (except P) was fed to SEW reared, high lean strain pigs during four stages of growth (9-36, 36-64, 65-92, and 92-119 kg BW). The basal diet contained .16, .128, .102 and .082% available P (AP), respectively, during four stages of growth. In each stage, six incremental additions of AP provided by either mono-dical or a combination of phytase (up to .08% AP) and mono-dical P were added to the basal diet. The incremental additions of AP were .08, .064, .052 and .041% during the four stages of growth. AP concentrations were based on analyzed P content of each ingredient adjusted for NRC (1998) estimates of P bioavailability and the equivalency of .08% AP for 363 FTU of phytase (Natuphos 5000)/kg diet. The dietary Ca:AP ratio was maintained at 2.5, 2.25, 2.0 and 2.0 for the 4 growth stages. Ten individually penned pigs (5 barrows, 5 gilts) were randomly allotted to each dietary treatment. The diet was provided in a meal form. Daily BW gain improved quadratically ( $P < .01$ ) as dietary AP concentrations increased independent of P source. Daily BW gains (pooled across P source and stage of growth) were 731, 866, 864, 865, 910, and 895 g, respectively, for the six AP concentrations and 857 and 853 g for the two AP sources. BW gain/feed ratios also improved quadratically ( $P < .01$ ) as dietary AP increased (.390, .429, .434, .426, .434, and .424 kg/kg) independent of P source. Efficiency of feed utilization tended to be improved ( $P < .15$ ) by the phytase-monodical AP source (.418 vs .426 kg/kg). Based on these data, growth responses of pigs fed equivalent dietary AP concentrations are largely independent of P source, P adequacy and stage of pig growth in animals fed corn-soy diets.

**Key Words:** Phosphorus, Phytase, Pigs

**126 Iron sources and amounts fed to sows during the last trimester of gestation do not enhance the ability of piglets to sequester iron.** N. J. Benevenga<sup>1</sup>, D. K. Schneider<sup>1</sup>, M. E. Glenn<sup>1</sup>, T. M. Fakler<sup>2</sup>, X. G. Luo<sup>3</sup>, and T. D. Crenshaw<sup>\*1</sup>, <sup>1</sup>University of Wisconsin, Madison, <sup>2</sup>Zinpro Corporation, Eden Prairie, MN, <sup>3</sup>Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, P.R. China.

Earlier observations in day-old pigs revealed that iron-binding capacity was essentially saturated at birth. Increasing the capacity of newborn pigs to sequester free iron should reduce the potential for Fe toxicity. In the current project sows at d 70 of gestation were fed diets with control amounts of Fe (200 mg Fe/kg diet), and either an additional 40 or 80 ppm Fe from iron amino acid complex (Availa®-Fe 60), or 80 ppm Fe from ferrous sulfate. Blood samples were collected on d 0, 10, and 20 from 307 pigs sub-sampled from 37 litters. Pigs were used to assess effects of Fe sources fed to sows on the ability of pigs to sequester Fe during the first three weeks. Pigs from each litter were blocked by weight

into groups of three and given either no Fe injection, or injections of 100 mg Fe from iron dextran on d 10 or d 0. No differences were detected in pig growth, survival, hematocrit, serum iron, total iron binding capacity (TIBC), or percent Fe saturation due to sow gestation diet. Growth over a 20-day lactation period was suppressed in pigs given no Fe injection or an Fe injection on d 10 compared with injections on d 0 (177, 197 and 230 g/d respectively), but pig survival was not compromised (91.4, 91.0, and 92.2%). Pigs given Fe injections on d 0 had higher ( $P \leq 0.05$ ) hematocrit and plasma Fe on d 10 and d 20 than pigs not given Fe injections, but TIBC was not different ( $P \geq 0.10$ ). Hematocrit and plasma Fe values of pigs not given Fe injections until d 10 recovered by d 20 to equal values as those given Fe injections on d 0. In conclusion, the sources nor amounts of supplemental iron fed to sows during the last trimester of gestation altered the piglet's ability to sequester iron injections.

Pig Fe	Hematocrit, %			Plasma Fe, $\mu\text{g/dL}$			TIBC, $\mu\text{g/dL}$		
	d 0	d 10	d 20	d 0	d 10	d 20	d 0	d 10	d 20
No Fe	31.7	18.0	14.7	94.0	63.7	54.1	357	707	735
Day 10	31.6	18.9	26.1*	89.3	64.7	72.7	354	701	784
Day 0	31.7	28.9*	25.8*	95.0	107.9*	77.7	352	759	779
SD	5.6	6.5	4.8	45.9	53.1	77.5	153	162	210

\* denotes difference ( $P \leq 0.05$ ) within a column from No Fe treatment.

**Key Words:** Iron, Sow, Hematocrit

## 127 Assessment of the feeding value of South Dakota grown field peas for growing pigs. H. H. Stein\*, R. A. Bohlke, V. Rayadurg, D. Peters, and R. C. Thaler, *South Dakota State University*.

Five experiments were conducted to evaluate the feeding value of South Dakota grown field peas (variety Carnival) for growing pigs. In exp. 1 and in exp. 2, 96 growing crossbred pigs (initial BW:  $22.3 \pm 1.48$  kg and  $26.7 \pm 1.18$  kg, respectively) were allotted to one of four treatment groups. In exp. 1, diets containing 0, 6, 12, or 18% peas were fed during the initial 6 wk of the experiment while 0, 12, 24, or 36% field peas were included in the finishing diets. In exp. 2, 0, 12, 24, or 36% peas were included in both the grower and the finisher diets. In both exp., ADG, ADFI, and GF were similar ( $P > 0.1$ ) between the four treatment groups. At slaughter, larger ( $P < 0.05$ ) loins were harvested from pigs fed diets containing 12% field peas in the finishing ration (exp. 1) or 12, 24, or 36% field peas (exp. 2). In both exp., the calculated lean meat percentage was similar ( $P > 0.10$ ) between treatment groups. In exp. 3 and 4, field peas were included in phase 2 diets for nursery pigs (initial BW:  $7.88 \pm 0.72$  kg and  $7.36 \pm 0.57$  kg, respectively) at levels of 0, 6, 12, or 18% (exp. 3) or 0, 12, 24, or 36% (exp. 4). These diets were offered to the pigs during wk 3-5 post-weaning. In both exp., ADG, ADFI, and GF were similar ( $P > 0.05$ ) between treatment groups. In exp. 5, the apparent (AID) and standardized (SID) ileal digestibility coefficients of crude protein and amino acids were determined for field peas and soybean meal in six growing barrows (Initial BW:  $36.5 \pm 2.1$  kg). AID for Met, Trp, Cys, and Ser were lower ( $P < 0.05$ ) in field peas than in soybean meal. When calculating SID, only Met was lower ( $P < 0.05$ ) for field peas than for soybean meal. Based on the results of these exp., it is concluded that South Dakota grown field peas provide a highly digestible source of amino acids that can replace soybean meal in diets for pigs. In phase 2 diets for nursery pigs and in diets for growing and finishing pigs, at least 36% field peas can be included without adverse effects on performance or carcass quality.

**Key Words:** Field Peas, Growing Pigs, Amino Acid Digestibility

## 128 A comparison of swine performance when fed diets containing Roundup Ready® (event NK603) or conventional corn lines. G. Bressner<sup>1</sup>, Y. Hyun<sup>\*1</sup>, E. Stanisiewski<sup>2</sup>, G. Hartnell<sup>2</sup>, and M. Ellis<sup>1</sup>, <sup>1</sup>University of Illinois at Urbana-Champaign, <sup>2</sup>Monsanto Company, St. Louis.

The objective of this study was to compare growth performance and carcass characteristics of growing-finishing pigs fed diets containing a Roundup Ready® corn hybrid (event NK603; line A), compared with a parental control line (line B) and two commercial lines of non-genetically modified corn (lines C and D). The study was carried out as a completely randomized design and compared four corn-line dietary treatments. A three-phase dietary program was used. Diets for the growing phase (30 to 50 kg BW) contained 1.02% total lysine; 18.5 % CP, and 3,370 kcal

ME/kg. For the early- (50 to 80 kg) and late - (80 to 120 kg) finishing phases diets were formulated to contain 0.78 and 0.67 % lysine, 15.0 and 13.5% CP, and 3,383 and 3,395 kcal ME/kg, respectively. All diets were formulated with a fixed level of corn inclusion which was 65, 74, and 77% for the growing and early- and late-finishing phases, respectively. A total of 160 commercial hybrid pigs (equal numbers of barrows and gilts) were reared from  $29.9 \pm 3.08$  to  $119.4 \pm 5.96$  kg BW in single-sex groups of five pigs and given ad libitum access to feed and water throughout the study. Pigs were raised in a controlled environment finishing facility having part-slatted, part-solid concrete floors and a floor space allowance of  $0.89 \text{ m}^2$ . At the end of the test period, pigs were slaughtered at a commercial plant and standard carcass measurements were taken. Pigs fed the four corn lines had similar ( $P > 0.05$ ) ADFI (2.45 to 2.54 kg; SEM 0.042), ADG (943 to 986 g; SEM 14.4), and gain:feed ratio (0.37 to 0.39; SEM 0.004). In addition, carcass measures (dressing percentage, carcass length, backfat thickness, and longissimus muscle area) were not different ( $P > 0.05$ ) among corn lines. Subjective scores for longissimus muscle color, firmness, and marbling taken at the 10th rib, were similar ( $P > 0.05$ ) among the corn lines. Gilts compared to barrows had lower ( $P < 0.01$ ) feed intake, growth rate, and backfat thickness but greater gain:feed ratio ( $P < 0.01$ ). The results of this study, carried out with growing-finishing swine, suggest that the Roundup Ready® (event NK603) corn hybrid tested is essentially equivalent in terms of nutrient composition and effects on growth and carcass characteristics to conventional corn hybrids.

**Key Words:** Roundup Ready® Corn, Growth Performance, Carcass Quality

## 129 Evaluation of copper chloride and copper sulfate as growth promoters in swine finishing diets. C.W. Hastad\*, S.S. Dritz, J.L. Nelssen, M.D. Tokach, and R.D. Goodband, *Kansas State University, Manhattan*.

Two trials were conducted to determine the effects of added copper from copper sulfate or copper chloride on performance of growing-finishing pigs. In Exp 1, 1,100 pigs (initially 33.7 kg) were weighed and randomly allotted to one of five dietary treatments. Diets were fed on a feed budget from d 0 to 115. Within each phase, treatment diets consisted of diets with no added copper (control), 50, 100, or 200 ppm of added copper from copper chloride or 200 ppm of added copper from copper sulfate. In Exp 2, 1,177 pigs (initially 31.2 kg) were weighed and randomly allotted to one of seven dietary treatments in a randomized complete block design with seven pens per treatment. Diets were fed in two phases from d 0 to 27 and d 27 to 56. Treatments consisted of a control diet with no added copper or 50, 100, or 200 ppm of added copper from either copper chloride or copper sulfate. In Exp 1, adding either copper source to the diet reduced ( $P < 0.02$ ) ADFI and improved ( $P < 0.05$ ) gain/feed (G/F) from d 0 to 31. When copper chloride was added to the diet, the greatest response in ADFI and G/F occurred with the first 50 ppm of copper. Adding copper to the diets also reduced ( $P < 0.05$ ) ADFI and improved G/F from d 58 to 86. Overall, pigs fed either copper source had reduced ( $P < 0.06$ ) ADFI and improved ( $P < 0.003$ ) G/F. Pigs fed copper sulfate had improved ADG ( $P < 0.003$ ) and pigs fed copper chloride had a trend ( $P < 0.07$ ) for improved ADG compared to pigs fed the control diet. In Exp 2, pigs fed either copper source had greater ADG ( $P < 0.01$ ) during the first two weeks of the experiment compared to pigs fed the control diet with no differences observed between copper levels or sources. Adding copper sulfate to the diets reduced ADFI ( $P < 0.03$ ) and copper chloride tended ( $P < 0.07$ ) to improve G/F for d 0 to 14. From d 14 to 27 and d 27 to 56, ADG, ADFI or G/F were not improved with copper additions to the diet. Adding low levels (50 to 100 ppm) of copper during the first four weeks of the growing-finishing phase provide increase gain and improve feed efficiency.

**Key Words:** Copper, Pigs

## 130 Evaluation of ground corn germ as an energy source in nursery pig diets. C.W. Hastad\*, M.D. Tokach, J.L. Nelssen, R.D. Goodband, and S.S. Dritz, *Kansas State University, Manhattan*.

Two hundred eighty nursery pigs (initially 14.0 kg) were used in a 21 d growth assay to compare ground corn germ as an energy source relative to corn oil in nursery pig diets. Pigs were blocked by weight and allotted to one of seven treatments. There were five pigs per pen and eight pens per treatment. Treatments included a corn-soybean meal control diet

with no added fat, additional diets included increasing amounts of oil (2, 4, and 6%) provided by either corn oil or corn germ. All diets were formulated to contain 3.82 g lysine/Mcal of ME. In diet formulation, corn germ was assumed to contain 50% of its weight as fat for an energy source. Pigs fed diets containing corn oil had improved ( $P < 0.04$ ) ADG, ADFI, and feed efficiency (G/F) compared to those fed diets containing ground corn germ. For the overall period, a fat source by level interaction was observed for G/F with G/F improved linearly when increasing levels of corn oil were added to the diet, whereas increasing fat from ground corn germ had no effect on performance. Pigs fed diets containing corn oil had decreased ( $P < 0.005$ ) ADFI and improved ( $P < 0.001$ ) G/F compared with pigs fed the control diet, however, ADG was not influenced ( $P > 0.10$ ). Pigs fed diets containing ground corn germ meal had growth performance similar to those fed the control diet with no added fat. These findings suggest that the energy in ground corn germ meal is not as available as the energy in corn oil for nursery pigs. Although corn germ would be expected to have a high energy value because of its fat content, its high fat content appears to be offset by a high fiber content (23.85% ADF and 43.36% NDF).

Fat Source Level	Corn Oil				Corn Germ			
	0	2	4	6	2	4	6	
ADG, g	742	758	758	765	745	733	751	
ADFI, g	1125	1139	1102	1077	1136	1124	1133	
Gain/Feed	0.66	0.67	0.69	0.71	0.66	0.65	0.66	

**Key Words:** Corn Oil, Corn Germ, Pigs

### 131 Growth performance and carcass characteristics of pigs fed diets containing a corn germ-corn bran product. S. J. Kitt\*, P. S. Miller, and R. L. Fischer, *University of Nebraska, Lincoln*.

The objective of this experiment was to determine the feeding value of a corn germ-corn bran mixture. A total of 34 (initial BW = 23.5 kg) barrows were used in a randomized complete block design experiment. Pigs were assigned to corn-soybean meal (C-SBM;  $n = 11$ ), corn-soybean meal-tallow (C-SBM-T; 4% Tallow;  $n = 11$ ), or corn-soybean meal-corn germ-corn bran (C-SBM-GB; 8% corn germ-corn bran;  $n = 12$ ) dietary treatments. Diets were formulated to contain a similar digestible lysine:NE ratio. Pigs were individually fed during the experimental period (93 d) in four phases (Phase 1, 23.5 to 37.5 kg; Phase 2, 37.5 to 59.5 kg; Phase 3, 59.5 to 86.5 kg; Phase 4, 86.5 kg to 112.0 kg). The true ileal digestible lysine:NE ratios (g/Mcal) were 4.40, 3.90, 3.14, and 2.31 for Phases 1 through 4, respectively. Diets were provided in meal form and pigs had ad libitum access to feed and water. For the entire experimental period, pigs fed the C-SBM-T diet had greater ADG than pigs fed the C-SBM-GB ( $P \leq 0.05$ ; 0.98 kg vs 0.92 kg, respectively). No differences ( $P \geq 0.26$ ) among treatments were observed for ADFI. Feed efficiency (ADG/ADFI) was different ( $P \leq 0.001$ ) among treatments and was greatest for pigs fed C-SBM-T (0.43), intermediate for pigs fed C-SBM (0.40), and lowest for pigs fed C-SBM-GB (0.38). Longissimus muscle area of pigs fed C-SBM-T was greater ( $P \leq 0.08$ ) than pigs fed C-SBM-GB. Pigs fed C-SBM tended to have greater ( $P \leq 0.10$ ) backfat depth than pigs fed C-SBM-T (21.2 vs 18.1 mm). Pigs fed C-SBM-T and C-SBM-GB had greater ( $P \leq 0.05$ ) lean percentage than pigs fed C-SBM. Fat-free lean gain was greater ( $P \leq 0.05$ ) in pigs fed C-SBM-T than pigs fed C-SBM or C-SBM-GB (402 g, 369 g, 355 g, respectively). These data suggest that pigs consuming diets containing a corn germ-corn bran product have reduced growth performance compared to pigs consuming C-SBM and C-SBM-T diets. The reduction in performance was likely due to the greater fiber concentration in the C-SBM-GB diets.

**Key Words:** Corn Germ-Corn Bran, Growth Rate, Pigs

### 132 Use of poultry byproduct meal as an alternate protein source in swine starter rations. C. Zier\*, M. Froetschel, R. Jones, and M. Azain, *University of Georgia, Athens, GA*.

A total of 200 crossbred pigs (initial wt = 6.5, kg) were weaned (21 d) and randomly allotted to four treatment groups in two replicates. In each replicate, pigs were placed into 20 pens with five pigs per pen, based on sex, weight, and litter. Treatments were designed to test inclusion of poultry by-product meal (PBM) in place of more commonly used animal protein sources. The phase I diets (1.5% lysine) included a basal diet containing both fish meal (FM, 5%) and spray dried porcine plasma (SDPP, 3%), and three test diets made to substitute SDPP, FM, or both

with PBM. Phase II diets (1.375% lysine) included a control diet with 2.5% blood meal (BM) and diets replacing BM, FM, or both with PBM. The phase I pelleted diets were fed for 5 days, the phase II pelleted diets were fed for 14 days, and a common phase III ground diet (1.25% lysine) was fed for 7 days. In phase I, ADG (211 vs. 158 g/d,  $P < 0.01$ ), BW (7.61 vs. 7.34 kg,  $P < 0.01$ ), and intake (205 vs. 175 g/d,  $P < 0.001$ ) in pigs fed diets containing the SDPP were greater than those fed PBM. Average daily gain from d 5 -12 was greater in pigs fed PBM than BM (191 vs. 152 g/d,  $P < 0.01$ ). Thus, differences in ADG for SDPP vs. PBM noted for phase I were negated by the end of the first week on the phase II diets. Overall (d 0-26), there was no difference in performance of pigs fed PBM in place of SDPP and BM. Substitution of PBM for FM in phase I or II had no effect on performance. These results indicate that PBM can be used in nursery diets in place of blood meal and fishmeal without affecting performance, but may not be equivalent to SDPP in phase I diets.

**Key Words:** Nursery, Pig, Poultry Byproduct Meal

### 133 Evaluation of pet food by-product as an alternative feedstuff in nursery pig diets. E.A. Jablonski\*, R.D. Jones, and M.J. Azain, *University of Georgia, Athens, GA*.

Early-weaned pigs ( $n=288$ , 5.2 kg at 14 days) were used in 2 replicates to evaluate pet food by-product (PFB) in nursery starter diets on growth performance. Pigs were allotted by sex, ancestry, and weaning weight to one of 4 dietary treatments in 32 pens with 8-10 pigs per pen, yielding a total of 8 pens per treatment. Using phase I and phase II diets, PFB (CP=22.1%, EE=8.29%, Ca=0.82%, P=0.84%) was substituted for more expensive animal-origin ingredients (plasma protein, fish meal, blood cells) at 0%, 10%, 30%, and 50% inclusion levels. Experimental diets were formulated to specific lysine requirements (1.50% and 1.35% for phase I and II, respectively) and to maintain relatively constant lysine to energy ratios, although protein increased with higher inclusion levels of PFB. Pigs were creep-fed a commercial pre-starter prior to phase I diets which were fed from days 0-7 post-weaning. Phase II diets were fed from days 14-21. On day 21, pigs were placed on a common phase III diet for 10 days. All experimental diets were fed in meal form. Blood samples were drawn from a total of 96 pigs in both replicates on day 14 and day 28. Serum was assayed for blood urea nitrogen levels to determine protein status. There were no treatment interactions across performance parameters. There was no effect of phase I diets on pig performance. In phase II diets, pigs that were fed PFB diets showed increased daily gain ( $P < 0.0001$ ) compared to the control. Average daily gain was 180, 249, 240 and 223 g/d for 0%, 10%, 30%, and 50%, respectively. Feed intake was also significantly increased ( $P < 0.0001$ ) during phase II (339, 431, 409, and 410 g/d for 0%, 10%, 30%, and 50%, respectively). There was a trend for improved feed/gain ( $P < 0.10$ ) with values of 1.89, 1.74, 1.71, and 1.84 for 0%, 10%, 30%, and 50%, respectively. There was no effect of dietary treatment on blood urea nitrogen levels. It appears that substituting PFB into nursery diets to replace more expensive animal protein products typically used is feasible.

**Key Words:** Nursery Pigs, By-Products, Growth Performance

### 134 Efficacy of Luctaplus® in improving performance of conventionally and segregated early-weaned pigs fed simple or complex diets. M.E. Davis\*<sup>1</sup>, C.V. Maxwell<sup>1</sup>, Z.B. Johnson<sup>1</sup>, B.Z. de Rodas<sup>2</sup>, D.C. Brown<sup>1</sup>, M.L. Gibson<sup>3</sup>, and E. Roura<sup>3</sup>, <sup>1</sup>University of Arkansas, Fayetteville, <sup>2</sup>Land O'Lakes, Fort Dodge, IA, <sup>3</sup>Lucta USA, Northbrook, IL.

Two experiments were conducted to determine the response of pigs reared in a conventional nursery (C) and segregated early-weaned (SEW) pigs to the addition of Luctaplus® (a combination of inorganic and organic acids, enzymes, and flavor) to diets varying in complexity. In Exp. 1, 216 barrows (5.7 kg BW; 19 d of age) were weaned, transported to off-site nursery facilities, blocked based on initial BW and penned in groups of six (9 pens/treatment). In Exp. 2, 96 pigs (6.7 kg BW; 19 d of age) were weaned in a C, blocked based on BW and sex and penned in groups of two (12 pens/treatment). In each experiment, treatments consisted of a 2 x 2 factorial arrangement of two levels of Luctaplus® (0 and 0.5%) added to either a simple or complex nursery diet. Treatments were fed throughout Phase 1 (10 d; 1.6% Lys), Phase 2 (14 d; 1.4% Lys), and Phase 3 (14 d; 1.25% Lys) of each experiment. In Exp. 1, G:F during Phase 1 improved ( $P < 0.05$ ) when pigs were fed the simple diet with

Luctaplus<sup>®</sup> compared to those fed the simple diet without Luctaplus<sup>®</sup>, whereas G:F was similar when the complex diet was fed regardless of Luctaplus<sup>®</sup> level (interaction,  $P < 0.05$ ). In the overall experiment (d 0 to 38), G:F improved ( $P < 0.05$ ) when pigs were fed 0.05% Luctaplus<sup>®</sup> compared to pigs fed diets devoid of Luctaplus<sup>®</sup>. In Exp. 2, ADG and G:F improved during Phase 1 and in the overall experiment (d 0 to 38) when pigs were fed the simple diet containing Luctaplus<sup>®</sup>, but was similar when pigs were fed the complex diet with or without Luctaplus<sup>®</sup> (interaction,  $P < 0.05$ ). Luctaplus<sup>®</sup> addition improved ( $P < 0.05$ ) ADG during Phase 3 and G:F from d 0 to 38 compared to pigs fed diets devoid of Luctaplus<sup>®</sup>. The addition of Luctaplus<sup>®</sup> improved pig performance in SEW pigs fed the simple diet or C pigs fed simple or complex diets, however, the greatest magnitude of response was observed in pigs fed the simple diet in C.

**Key Words:** Nursery Pigs, Acidification, Enzymes

### 135 The effect of floor-feeding on post-weaning piglet weight gain. N.R. Augspurger\*, T.M. Parr, and D.H. Baker, *University of Illinois at Urbana-Champaign.*

Two experiments were done to investigate means of increasing weight gain through floor-feeding of newly-weaned piglets. In both trials, piglets were offered a complex starter diet (3-mm pellet) on a rubber mat (55 cm  $\times$  55 cm  $\times$  1 cm) positioned in front of a five-hole self-feeder three times daily. The objective of Exp. 1 was to determine the effect of floor-feeding both pre- and post-weaning on piglet growth. One hundred ninety-two piglets (5.2 kg) from 24 litters, were used in a split-plot design with a  $2 \times 2$  factorial arrangement of treatments. Litters of eight suckling pigs were paired and assigned to control or floor-feeding treatments from 18 to 21 d of age. The floor-mat was positioned at the front and to one side of the farrowing crate. After weaning, each litter was split according to body weight into two groups of four, which were allotted to either control or floor-feeding treatments for the first 3-d post-weaning, after which the only source of feed was the feeder. Floor-fed piglets were offered 250 g of diet on the floor-mat three times daily in each phase. Body weights were taken at weaning and at d-7 post-weaning. Floor-feeding in the crate did not affect piglet weight gain from d 18 to 21, although piglets that were floor-fed during lactation tended to have higher weight gains from d 18-28 (240 vs 213 g/d,  $P < .10$ ). Piglet weight gain was not affected by floor-feeding in the nursery. Exp. 2 was designed to determine the effect of duration of post-weaning floor-feeding on weight gain of piglets. One hundred fifty newly-weaned pigs (6.0 kg) were randomly assigned (10 replicates/treatment and 5 pigs/pen) to one of three floor-feeding durations: zero, three or seven days. Floor-feeding was carried out as in trial 1, with the exception that 500 g of feed was fed at each feeding. Final body weights were measured on d 7. Weight gain of piglets from d 0 to 3 was numerically higher, albeit not significantly, for floor-fed piglets. Feed intake from feeders was reduced ( $P < .01$ ) in floor-fed piglets. Floor-feeding did not significantly affect weight gain of piglets over the first week post-weaning. In these experiments, floor-feeding did not improve weight gain of piglets immediately post-weaning.

**Key Words:** Piglets, Floor-Feeding

### 136 The influence of dietary energy on the response to betaine in finishing pigs. M. G. Young\*, S. S. Dritz, M. D. Tokach, R. D. Goodband, and J. L. Nelssen, *Kansas State University, Manhattan.*

A total of 800 pigs (PIC barrows) were used to evaluate the influence of dietary energy on the response to betaine in finishing pig diets. Pigs were housed in a 48-pen curtain-sided, total slatted, commercial research, finishing barn with 0.67 m<sup>2</sup> pig, 25 pigs/pen, and 7 pens/treatment. Treatments were arranged in a  $2 \times 2$  factorial with or without betaine and two energy densities. All diets were corn-soybean meal based with the low energy diet containing no added fat and the high-energy diet containing 5 or 6% added fat depending on the phase. Betaine was included at 0.14% of the diet replacing corn in the treatment diets to provide 1,000 ppm of betaine (FinnFeeds International). Diets were fed in three phases from 23 to 43 kg, 43 to 68 kg and 68 to 95 kg. Each phase was fed for approximately 28 days. No betaine by energy interactions ( $P > 0.11$ ) were observed. Adding betaine to the diet did not affect ( $P > 0.05$ ) pig performance. Pigs fed diets without and with betaine had ADG of 0.874 and 0.862 kg/d and gain/feed of 0.44 and 0.43, respectively. From 23

to 43 kg, ADFI decreased ( $P < 0.01$ ) and feed efficiency improved ( $P < 0.01$ ) with increasing dietary energy density. From 43 to 68 and 68 to 95 kg, increasing the energy density increased ( $P < 0.05$ ) ADG, and improved ( $P < 0.01$ ) feed efficiency. For the overall experiment, pigs fed the high-energy diet had ( $P < 0.05$ ) higher ADG (0.889 vs 0.847 kg/d), lower ADFI (1.95 vs 2.06 kg/d), and improved G/F (0.46 vs 0.41) compared with pigs fed the low energy diets. Adding fat to the diet from 23 to 95 kg resulted in 5 and 10% improvements in ADG and F/G, respectively. In conclusion, we failed to observe improvements in growth performance when adding betaine to corn-soybean meal or corn-soybean meal added fat diets regardless of dietary energy concentration.

**Key Words:** Betaine, Energy, Finishing Pigs

### 137 Influence of dietary supplementation with $\beta$ -mannanase on performance of finishing pigs in a commercial system. P. R. O'Quinn\*, D. W. Funderburke<sup>1</sup>, C. L. Funderburke<sup>1</sup>, and R. L. James<sup>2</sup>, <sup>1</sup>Cape Fear Consulting, LLC, Warsaw, NC, <sup>2</sup>ChemGen Corp., Gaithersburg, MD.

Pigs (n = 5,350) from a six barn commercial finishing facility were used to determine the efficacy of supplemental dietary  $\beta$ -mannanase. This source of  $\beta$ -mannanase (Hemicell<sup>®</sup>) was supplied by ChemGen Corp., Gaithersburg, MD. Pigs (initially 18.8 kg) of Dekalb genetics were balanced for sex, and fed a corn-soybean meal based diet in meal form throughout the 20-wk growing period.  $\beta$ -mannanase was included at the rate of 0.05% in the experimental diets; assays were conducted to verify proper inclusion. Diets were delivered by separate feed lines within each barn, resulting in six replications per treatment. Benefits of feeding  $\beta$ -mannanase were observed in percentage mortality and culls/lightweights. Mortality tended ( $P = 0.09$ ) to be reduced; the reduction was 23.7%. Similarly, culls and lightweight pigs were reduced ( $P < 0.001$ ) by 59.6%. Pigs fed  $\beta$ -mannanase had increased ADG ( $P = 0.04$ ). ADFI was increased by 3.2% ( $P = 0.004$ ), while G/F was unaffected ( $P = 0.22$ ) by dietary treatment. Based on the processing data from 3,975 pigs, it appears the additional gain was primarily in the form of fat, as fat depth was increased ( $P = 0.005$ ) and calculated percentage lean was decreased ( $P = 0.002$ ) in pigs fed  $\beta$ -mannanase. This may indicate a need to reduce the dietary energy content when feeding  $\beta$ -mannanase. Dressing percentage tended to be increased ( $P = 0.08$ ) by feeding  $\beta$ -mannanase. Loin depth was unaffected ( $P = 0.18$ ). As expected, gilts had less fat thickness ( $P = 0.001$ ) and more loin depth ( $P = 0.001$ ) than barrows regardless of dietary treatment. Total payment per pig tended ( $P = 0.11$ ) to be higher for pigs fed  $\beta$ -mannanase. The base pay for carcass weight was higher and the lean premium was slightly lower. These data indicate that supplemental dietary  $\beta$ -mannanase may be beneficial for commercially reared finishing pigs.

**Key Words:** Pigs,  $\beta$ -mannanase, Growth Performance

### 138 Bone integrity in response to changes in dietary energy intake. B.C. Robbins\*, T.D. Crenshaw<sup>1</sup>, J.F. Patience<sup>2</sup>, and R.D. Boyd<sup>3</sup>, <sup>1</sup>University of Wisconsin, Madison, <sup>2</sup>Prairie Swine Center, Inc. Saskatoon, SK, <sup>3</sup>PIC, Inc. Franklin, KY.

One hundred sixty-six growing pigs (83 gilts and 83 barrows) from the Prairie Swine Center in Saskatoon were subjected to five levels of diet restriction (72, 79, 86, 93, or 100% of ad libitum) and slaughtered at five target weights (25, 50, 75, 100, or 120 kg) to validate the accuracy of a growth model in the prediction of swine body composition. Sixteen pigs slaughtered at 25 kg served as a baseline. After slaughter, hind feet were collected and shipped to Wisconsin for assessment of skeletal integrity. Fourth metatarsals were collected from each foot for geometric measures, ash content, subjective assessment of OCD lesions, and mechanical properties determination. A three-point bending test was used to establish the mechanical properties. After the mechanical tests were conducted, a cross section of the mid-diaphysis was cut in order to determine the area moment of inertia. Metatarsal bone length, mid-diaphysis diameter, cortical thickness, ash weight, and percent ash increased as target slaughter weight increased ( $P < 0.01$ ). Bending moment and stress at both the yield point and the ultimate point increased linearly as target weight increased ( $P < 0.001$ ). The modulus of elasticity reflected patterns similar to bending moment and stress. There were no differences detected in bone strength due to diet restriction, this may be related to the differences in animal age at slaughter. The older animals (i.e. diet restricted) killed at the same target weight, as ad libitum fed animals, had longer bones and a greater ash content ( $P < 0.01$ ).

Based on results, the quality of bone produced by rapidly growing pigs was the same as bones from animals that were restricted-fed; however, these results were confounded with animal age.

**Key Words:** Bone, Diet Restriction, Mechanical Properties

**139 Effectiveness of Tylan or a direct fed microbial to reduce pig variation.** C.A. Elmore\*, G.A. Apgar, and K.E. Griswold, *Southern Illinois University, Carbondale*.

One hundred and eight pigs (crossbred sow x PIC 337) were used to evaluate the effect of an antimicrobial (Tylan) or a direct fed microbial (*B. coagulans*) to pig to pig variation during finishing. Pigs were weighed and allotted to outcome groups based on sex (approximately 4 females and 5 males per pen), weight and genetic background, and were randomly assigned to one of three dietary treatments. Treatments were as follows: 1) control, 2) Control + Tylan (40 g/ton), and 3) Control + *B. coagulans* ( $9.98 \times 10^{11}$  CFU/ton). Pigs were allowed ad libitum access to feed and water at all times. All pigs were weighed and feed intake and feed efficiency calculated bi-monthly, or intermittently depending upon diet change. Data were analyzed using the GLM procedure of SAS and differences among dietary treatments were analyzed using contrast statements. There were no significant differences between dietary treatments during the first 8 d for weight, ADG or G:F. Coefficients of variation for these criteria also were not altered by dietary treatment. From d 8 to d 19, pigs fed diet 3 tended ( $P < .07$ ) to be heavier, than pigs fed the control treatment, with pigs fed diet 2 falling intermediate. Average daily gain was numerically greater for pigs fed diet 3 as compared with controls. Coefficients of variation tended ( $P < .08$ ) to be lower for ADG during this period for pigs fed treatment 3 when compared with pigs fed the control. Pigs fed treatment 2 were intermediate. Variation in BW for pigs fed the control treatment numerically increased over time, while BW of pigs fed treatments 2 and 3 numerically decreased. Our initial data suggest feeding a direct-fed microbial may reduce variation in growth rate.

**Key Words:** Finishing, Direct Fed Microbial, Tylan

**140 Influence of crystalline or protein-bound lysine on lysine utilization for growth in nursery pigs.** J. J. Colina\*, P. S. Miller, A. J. Lewis, and R. L. Fischer, *University of Nebraska, Lincoln*.

A 4-wk experiment was conducted to determine the efficiency of utilization of crystalline lysine relative to the lysine in soybean meal for growth performance and effects on plasma urea concentrations in nursery pigs. Pigs were 23 to 24 d old and had an initial BW of 6 kg. Pigs were blocked by sex and weight (three blocks of barrows and three blocks of gilts) and randomly allotted to one of five dietary treatments. Pigs were individually penned in two nursery facilities and each treatment was replicated six times. The dietary treatments consisted of a basal diet (1.05% lysine) and diets containing 1.15 and 1.25% lysine that were achieved by adding lysine to the basal diet from either soybean meal (SBM) or L-lysine-HCl (CRYST). Average daily gain and ADFI were measured weekly. Blood samples were collected on the last day of the experiment and plasma was analyzed for urea concentration. Data were analyzed as a randomized complete block design with repeated measurements in time. Feed efficiency (ADG/ADFI) was similar ( $P > 0.1$ ) among treatments. By the 4<sup>th</sup> wk, ADG was greater ( $P < 0.05$ ) for pigs fed the diet supplemented with 1.15% lysine from SBM in comparison with pigs fed the diet supplemented with 1.25% lysine from CRYST. In addition, ADFI was greater ( $P < 0.1$ ) for pigs fed the 1.25% lysine supplemented from SBM vs CRYST (1.20 vs 1.06 kg). Pigs fed diets supplemented with SBM had greater ( $P < 0.001$ ) plasma urea concentrations than pigs supplemented with CRYST. Although preliminary data (not shown) and lysine requirements derived from NRC (1998) support that the aforementioned lysine concentrations were within the deficient range for nursery pigs (5 to 10 kg), data from this experiment do not indicate that lysine intake was limiting growth. Therefore, conclusions regarding the efficiency of lysine utilization for growth from L-lysine-HCl and soybean meal can not be made.

**Key Words:** Pigs, Lysine, Growth

**141 Evaluation of the lysine requirement for 11 to 25 kg barrows.** D. C. Kendall\*<sup>1</sup>, G. Yi<sup>1</sup>, A. M. Gaines<sup>1</sup>, G. L. Allee<sup>1</sup>, J. L. Usry<sup>2</sup>, M. Steidinger, and W. Cast, <sup>1</sup>*University of Missouri-Columbia*, <sup>2</sup>*Ajinimoto Heartland Inc.*

A 21d experiment was conducted to determine the lysine requirement for 11 to 25 kg barrows ( $n=252$ , Dalland x PIC C-22). Pigs were allotted in a randomized complete block design and were fed one of 7 dietary treatments with 9 replicates/treatment and housed at 4 pigs/pen. Dietary true ileal digestible (TID) lysine levels were 1.05, 1.13, 1.19, 1.26, 1.33, and 1.40% TID lys with all diets containing the same inclusion of soybean meal (33.1%). Dietary lysine content was increased by adding Lys-HCl (0, .09, .178, .267, .356 and .445%, respectively). A positive control diet was formulated at 1.40% TID lys, containing .15% added Lys-HCl and 42.0% soybean meal. All diets were formulated to be equal on a ME basis (3.42 Mcal ME/kg) with additional synthetic amino acids supplied as necessary to meet minimum amino acid ratio requirements. Pigs were weighed weekly to determine average daily gain, average daily feed intake and feed efficiency. During d 0-7, there was a linear improvement in ADG and G:F ( $P < .05$ ) with increasing TID lysine level, up to 1.33%. During d 7-14, there was a linear improvement in G:F ( $P < .05$ ) with a plateau occurring at 1.33% TID lys. From d 14-21, a linear trend ( $P < .10$ ) existed for ADG and G:F with improvements up to 1.19% TID lys. For the overall period, ADG and G:F were linearly improved ( $P < .05$ ) with increasing lysine levels, up to 1.33% TID lys. The 1.40% TID lys diet did not differ from the positive control diet in any criteria measured. This experiment demonstrates that the lysine requirement for pigs from 11 to 25 kg BW may be as high as 1.33% TID lys and the inclusion Lys-HCl up to .445% does not affect performance of nursery pigs.

**Key Words:** Pigs, Lysine, Nursery

**142 Effects of plasma grade, irradiation or formaldehyde treatment of plasma, or whole diet irradiation on growth performance of weaned pigs.** D. R. Cook\*, M. M. Ward, and N. D. Paton, *Akey Inc. Lewisburg, OH*.

Two experiments were conducted to determine the impact of reducing colony-forming units (CFU) in plasma or whole diet on weaned pig growth performance. In Exp. 1 (1760 18-d old pigs, 5.4 kg, 22 pigs/pen, 0.25 m<sup>2</sup>/pig), two sources of plasma (human grade, HGP; and technical grade, TGP), and three processes (non-processed, NP; irradiated, IR; or Termin-8, T8) were tested in a 2 x 3 factorial arrangement of treatments. Plasma sources were added to diets on an equal protein basis at approximately 5% and 2% of the diet from 0-7 and 8-14 d post weaning, respectively. Irradiation for IR treatment was 5-20 kGy. T8 (a formaldehyde product) was atomized and added directly to the plasma at 0.3% for the T8 treatment. Pigs were blocked based on BW and sex and pens were allotted to treatment within block. TGP and HGP had pre-IR total CFU/g of 21,700 and 375, respectively. IR reduced CFU/g to 135 and 60 for TGP and HGP, respectively. Pigs fed TGP plasma tended to have greater ADG ( $P < .10$ ) and ADFI ( $P < .08$ ) versus pigs fed HGP. There were no significant performance differences ( $P > .10$ ) among NP, IR or T8-fed pigs during the 14 d feeding period. No interactions were observed between plasma source and processing method. In Exp. 2, 880 pigs were reared under the same conditions as in Exp. 1. Pigs were fed NP or IR diets for 22 d followed by a common NP diet. Irradiating whole diet reduced CFU/g but also decreased growth performance d 0 to 5 post-weaning (ADG 159 vs. 174 g;  $P < .10$ ) and feed intake (149 vs. 165 g/d;  $P < .06$ ). Similar results were observed d 15 to 23 post-weaning for ADG (365 vs. 379 g;  $P < .08$ ) and G/F (0.73 vs. 0.76;  $P < .001$ ). For the 45-d trial, IR did not alter growth performance. In conclusion, irradiation of plasma was an effective tool in reducing microbial contamination but did not improve growth performance in these experiments. Whole diet IR appears to have a negative impact on early nursery growth performance.

**Key Words:** Pigs, Irradiate, Termin-8

**143 Effects of ingredient and whole diet irradiation on nursery pig performance.** J.M. DeRouchey\*, M.D. Tokach, J.L. Nelssen, R.D. Goodband, S.S. Dritz, J.C. Woodworth, M.J. Webster, and B.W. James, *Kansas State University, Manhattan*.

A total of 880 pigs ( $15 \pm 2$  d of age) were used in two experiments to determine the effects of irradiation of individual ingredients or whole diet

on growth performance of nursery pigs. Pigs had an initial BW of 4.9 kg in Exp. 1 and 5.1 kg in Exp. 2. There were eight pigs/pen in both experiments with five pens/treatment in Exp. 1 and six pens/treatment in Exp. 2. Pigs were blocked by weight and allotted to one of ten dietary treatments. Both experiments contained similar treatments that first included a control diet that contained ingredients that were not irradiated. Other treatments included diets that had specific ingredients irradiated: corn, soybean meal, spray-dried whey, spray-dried animal plasma, fishmeal, soybean oil, or all microingredients combined (antibiotic, vitamins, minerals, crystalline amino acids). The final two treatments included a diet that contained all ingredients that had been irradiated and a diet that was manufactured with nonirradiated ingredients and subsequently irradiated. An average irradiation dose of 8.5 kGy was used. No experiment  $\times$  treatment interactions were observed. Overall (d 0 to 14 in trial 1 and d 0 to 12 in trial 2), pigs fed diets containing irradiated spray-dried animal plasma or soybean meal had increased ( $P < 0.05$ ) ADG compared to the control diet with no irradiated ingredients and the complete diet that was irradiated. Also, ADFI ( $P < 0.05$ ) was greater for pigs consuming the diet with irradiated soybean meal compared to those fed the irradiated whole diet. Finally, pigs fed irradiated spray-dried animal plasma had improved gain/feed ( $P < 0.05$ ) compared to those fed diets containing irradiated microingredients or if all ingredients had been irradiated before manufacturing. In summary, irradiation of certain feed ingredients (spray-dried animal plasma or soybean meal in these experiments) can improve growth performance in nursery pigs, whereas irradiation of all ingredients or the whole diet does not enhance performance.

**Key Words:** Nursery Pig, Feed Ingredients, Irradiation

**144 Comparison of irradiated feed and food grade spray-dried animal plasma on nursery pig performance.** J.M. DeRouchey\*, M.D. Tokach, J.L. Nelssen, R.D. Goodband, S.S. Dritz, J.C. Woodworth, and C.W. Hastad, *Kansas State University, Manhattan.*

A total of 535 weanling pigs ( $17 \pm 2$  d of age) were used (initial BW of 6.3 kg in Exp. 1 and 6.1 kg in Exp. 2) to determine the effects of initial bacterial concentrations of spray-dried animal plasma on growth performance. Previous research indicates that pigs fed irradiated feed-grade animal plasma (initially high bacteria) have improved growth performance compared to those fed non-irradiated feed-grade animal plasma. Therefore, we hypothesized that irradiation of food grade plasma (initially low bacteria) may lead to a lower growth performance response. All pigs were blocked by weight with five pigs per pen and six and seven pens/treatment in Exp. 1 and 2, respectively. In Exp. 1, pigs were allotted to one of nine treatments including a control diet or the control with 5% plasma from one of four different sources either fed irradiated or as-is. Plasma sources were from American Protein Corporation, Ames, IA (feed grade, AP 920 and AP 820; and food grade, source 1 and 2). In Exp. 2, five diets were used from Exp. 1, which included the control, and plasma sources, AP 820 and food grade, fed irradiated or as-is. Pigs fed animal plasma had increased ADG (Exp. 1 & 2), ADFI (Exp. 1) and G:F (Exp. 2;  $P < 0.05$ ) compared to pigs fed the control diet. In Exp. 1, pigs fed irradiated AP 920 feed grade plasma had increased ADG ( $P < 0.05$ ) compared to those fed the control diet. Also, pigs fed irradiated AP 920, regular AP 820, regular and irradiated source 1 food grade and regular source 2 food grade had improved ADFI compared to pigs fed the control diet. In Exp. 2, pigs fed irradiated AP 820 had increased ADG ( $P < 0.05$ ) compared to those fed the control diet and pigs fed regular AP 820. Irradiation of food grade plasma did not influence ( $P > 0.12$ ) pig performance in either experiment. These studies indicate that reducing initial bacterial levels in animal plasma leads to increased growth of nursery pigs, and may explain the variation in response when animal plasma is included in diets for nursery pigs.

**Key Words:** Nursery Pig, Animal Plasma, Irradiation

**145 The effect of varying levels of spray-dried animal plasma in nursery pig diets.** C. S. Stovall\*, G. A. Apgar, and K. E. Griswold, *Southern Illinois University, Carbondale.*

A total of 193 crossbred weanling pigs (avg  $24 \pm 0.5$  d and  $6.5 \pm 1.5$  kg in Trial 1, and  $19 \pm 0.7$  d and  $5.6 \pm 0.9$  kg in Trial 2) were used in two trials to determine the effect of adding varying levels of spray-dried animal plasma (SDAP) to phase one nursery diets. Pigs were blocked by initial

weight, sex and litter, and were randomly assigned to one of four treatment diets. Pigs were housed in an environmentally controlled modular nursery with 12 pens and an average of 12 pigs per pen (Trial 1) and 7 pigs per pen (Trial 2). Pigs were allowed ad-libitum access to feed and water for the duration of each trial. All diets met or exceeded current nutrient requirement estimates (NRC, 1998). Lysine levels were equalized across dietary treatments by substitution with blood meal. Choice white grease was added when needed to make the diets isocaloric. The dietary treatments were as follows: 1) 0% SDAP (control), 2) 3% SDAP, 3) 6% SDAP, 4) 9% SDAP. Pigs were weighed, feed intake and feed efficiency calculated weekly. The treatment diets were fed from d 0-14 post-weaning after which a common corn-soybean meal diet was fed to all pigs d 14-35 post-weaning. Data from the two trials were analyzed using the GLM procedure of SAS and orthogonal contrasts were used to estimate linear, quadratic and cubic treatment effects and individual means were separated by the LSD procedure. In Trial 1, there were no significant effects of SDAP addition on ADG or ADFI. Feed efficiency was affected in a quadratic manner ( $P < .05$ ) during wk 3, 5 and 3 through 5 with pigs fed 0 and 9% SDAP having numerically similar G:F and pigs fed 3% and 6% SDAP having numerically lower efficiencies. In Trial 2, ADG and ADFI were improved linearly ( $P < .05$ ) during wk 1, and ADFI was improved linearly ( $P < .05$ ) during wk 4. Efficiency of gain was improved in a linear manner ( $P < .05$ ) during wk 1, 1 through 2 and 1 through 5. These data suggest that SDAP addition improves performance of pigs weaned at 19 days of age as compared with pigs weaned at 24 days of age.

**Key Words:** Spray-Dried Animal Plasma, Weanling Pig, Performance

**146 A comparison of roller-dried whey and spray-dried whey in swine starter diets.** G. F. Yi\*, G. L. Allee<sup>1</sup>, A. M. Gaines<sup>1</sup>, D. C. Kendall<sup>1</sup>, K. M. Halpin<sup>2</sup>, and M. Trotter<sup>2</sup>, <sup>1</sup>*University of Missouri-Columbia*, <sup>2</sup>*International Ingredient Corporation, Inc.*

A total of 200 weaned barrows and gilts (5.360.3kg, 100 each) at 19 2 days of age were used to compare the effects of roller-dried whey (RDW) and extra grade spray-dried whey (SDW) on the growth performance of young pigs. The pigs were randomly allotted by initial BW and sex to five dietary treatments in a RCBD, with ten replicate pens per trt and four pigs per pen. During day 0 14, 14 28 and 28 42, the pigs were fed Phase I, Phase II and Phase III diets respectively. During Phase I, a corn-soy diet without any whey product served as a control (Trt A). Treatments B to E contained 10%SDW, 10%RDW, or 20%SDW or 20%RDW respectively. In Phase II treatments B to E contained 5%SDW, 5%RDW, or 10%SDW or 10%RDW respectively with a corn-soy diet without any whey as the control (Trt A). In Phase III, all the pigs were fed the common diet. Pigs were weighed and feed intake recorded on d 7, 14, 28, and 42. BW, ADG, ADFI and G:F were used to evaluate growth performance. In the first week, ADFI and ADG were increased by whey addition, with the 20% whey diets, resulting in a greater response than that of 10% whey ( $P < 0.05$ ). There were no differences due to whey source (RDW vs. SDW) ( $P > 0.05$ ). During Phase I, compared to the control, the ADFI was linearly increased with the increasing level of either RDW or SDW ( $P < 0.05$ ). In Phase II, there were no differences in growth performance ( $P > 0.05$ ). However, in Phase III, pigs fed 10% or 20% whey in Phase I tended to gain faster ( $P < 0.10$ ) with an improved feed efficiency ( $P < 0.05$ ) compared to the pigs fed the control diet. Overall, pigs fed 20% whey in Phase I diets were approximately 1.0 kg heavier after the 42 d nursery period compared to the pigs fed the control diet. These results indicate that both RDW and extra grade SDW improved the growth performance of weaned pig with no differences between whey processing methods.

**Key Words:** Weaned pigs, Whey, Starter diets

**147 Non-pasteurized, spray-dried egg treated with Termin-8 as a protein source for phase 1 nursery diets.** M.E. Davis\*, C.V. Maxwell<sup>1</sup>, Z.B. Johnson<sup>1</sup>, D.C. Brown<sup>1</sup>, S. Singh<sup>1</sup>, K.J. Touchette<sup>2</sup>, and J.A. Coalson<sup>2</sup>, <sup>1</sup>*University of Arkansas, Fayetteville*, <sup>2</sup>*Merrick's Inc., Union Center, WI.*

A conventional nursery trial with 144 crossbred weanling pigs was conducted to determine the efficacy of non-pasteurized, spray-dried egg product (EGG) with and without treatment with Termin-8 (a formaldehyde-based antimicrobial preservative; T-8) to replace spray-dried plasma (SDP) in the Phase 1 (d 0 to 14) nursery diet. Pigs ( $21 \pm 1$  d of age; 6.6 kg BW) were assigned by initial weight and sex to 1

of 8 treatments in a randomized complete block designed experiment. There were 6 blocks with 3 pigs/pen and 6 pens/treatment. Eight diets were fed during phase 1: 1) a negative control diet devoid of egg product and SDP, 2) a positive control diet containing 5% SDP added at the expense of soybean meal, 3, 4, 5) as 2 with EGG treated with T-8 replacing 25, 50 or 75% of the SDP, 6, 7, 8) as 2 with EGG not treated with T-8 replacing 25, 50 or 75% of the SDP. All diets were formulated on an equal lysine basis (1.5% lysine). Upon completion of the Phase 1 diet, a common Phase 2 diet (1.35% lysine) was fed from d 14 to 28 postweaning. Treatment means and interactions ( $P < 0.05$ ) are presented. Pigs fed the negative control diet in Phase 1 had a reduced ADG compared to those fed all EGG treatments (115 vs. 153 g/d,  $P < 0.03$ ). During Phase 2, pigs previously fed the positive control diet had reduced G:F when compared to those previously fed EGG (0.747 vs. 0.780,  $P < 0.02$ ). These results indicate that ADG is enhanced in Phase 1 nursery diets with low inclusion levels of EGG and that the efficacy of EGG is enhanced with T-8 treatment.

Item	Neg. Cont.	Pos. Cont.	EGG 25%	with 50%	T-8 75%	EGG 25%	W/O 50%	T-8 75%	SEM
ADG, g									
Phase 1 <sup>a,b</sup>	115	185	194	149	158	148	116	155	15
Phase 2	592	590	569	561	556	566	563	565	28
G:F									
Phase 1 <sup>a</sup>	0.56	0.75	0.73	0.64	0.66	0.59	0.56	0.59	0.04
Phase 2 <sup>a</sup>	0.84	0.75	0.76	0.78	0.78	0.78	0.89	0.77	0.01

<sup>a</sup>Neg. control vs Pos. control ( $P < 0.01$ ). <sup>b</sup>Egg source x level effect ( $P < 0.02$ ).

**Key Words:** Egg Product, Diet, Nursery Pigs

#### 148 Effects of mannanoligosaccharides in diets for nursery pigs. J. D. Hancock\*, C. L. Jones, and C. W. Starkey, Kansas State University.

A total of 168 weanling pigs (average initial BW of 6.0 kg) were used in a 35-d experiment to determine the effects of mannanoligosaccharides on growth performance of nursery pigs. The diets were corn-soy-based and formulated to 1.8% lysine for d 0 to 7, 1.6% lysine for d 7 to 21, and 1.4% lysine for d 21 to 35. Treatments were: 1) a positive control with carbadox (55 g/ton of diet); 2) a negative control without antibiotic; 3) the negative control with mannanoligosaccharides from dried *Saccharomyces cerevisiae* fermentation solubles (Bio-Mos); and 4) the negative control diet with mannanoligosaccharides from the cell walls of yeast (Safmannan). For d 0 to 7 and 7 to 21, the diets were pelleted and for d 21 to 35, the diets were fed in meal form. As for growth performance, ADG and gain/feed were not different ( $P > 0.36$ ) for pigs fed the diet with antibiotic vs the other treatments for d 0 to 7. However, this lack of difference was the result of good growth performance among pigs fed the diets with mannanoligosaccharides vs the negative control (i.e.,  $P < 0.07$  for ADG and  $P < 0.02$  for gain/feed). Overall (d 0 to 35), ADG was greater ( $P < 0.02$ ) for pigs fed diets with antibiotic vs the other treatments and for pigs fed diets with mannanoligosaccharides vs the negative control ( $P < 0.04$ ). Pigs fed diets with mannanoligosaccharides had greater gain/feed than pigs fed the negative control ( $P < 0.002$ ), but there were no differences in ADG, ADFI, or gain/feed among pigs fed diets with the two different sources of mannanoligosaccharides ( $P > 0.49$ ). Analyses of fecal samples collected on d 38 and 39 indicated no effect of any treatment on colony forming units of total coliform or *E. coli* ( $P > 0.54$ ). In conclusion, mannanoligosaccharides had a positive effect on growth performance of weanling pigs. Those effects were not associated with changes in coliform concentrations in the feces and apparently were caused by other physiological effects.

Item	Contrast							
	Anti	None	B-Mos	Saf	Se	others	mann	Saf
d 0 to 35								
ADG, g	460	397	426	425	10	0.002	0.04	-
ADFI, g	606	562	562	557	15	0.02	-	-
Gain/feed, g/kg	759	706	758	763	8	0.11	0.001	-

**Key Words:** Pig, Mannanoligosaccharide, Growth

#### 149 Effect of dietary mannanoligosaccharide (MOS) and sodium chlorate (CHL) on growth performance of weaned pigs challenged with *Salmonella enterica* serotype typhimurium (ST). T. E. Burkey\*, S. S. Dritz, J. C. Nietfeld, B. J. Johnson, and J. E. Minton, Kansas State University.

Concern about the use of antimicrobials in livestock feed has lead to a search for alternatives. Our study was conducted to evaluate two additives, MOS and CHL, as alternative growth promotants in weaned pigs undergoing ST disease challenge. Weaned pigs ( $n=96$ ;  $6.8 \pm 1.3$  kg initial weight) were blocked by weight and assigned to four treatments. The negative control diet contained no additive (CON), while the positive control contained carbadox (CARB; 55 ppm). Test diets contained MOS (1500 ppm) or CHL (800 ppm). There were 12 pens/treatment with 2 pigs/pen. Pigs were fed diets for 2 wk. Then, all pigs were given ST orally, and the study continued for an additional 2 wk. Body weights and feed intake were measured weekly to calculate average daily gain (ADG), feed intake (ADFI) and feed efficiency (G/F). ADG was greater in pigs fed CARB during wk 1 and 2 compared to MOS- and CHL- treated pigs ( $P < .05$ ), and was greater than CON pigs during wk 2 ( $P < .05$ ). During wk 3 (ST challenge week), ADG did not differ between CON ( $.15 \pm .04$  kg/d), MOS ( $.22 \pm .04$  kg/d) and CHL ( $.24 \pm .04$  kg/d), but all were less ( $P < .05$ ) than CARB ( $.37 \pm .04$  kg/d). This advantage in ADG continued for the CARB treatment into the final week of the study ( $P < .05$ ). ADFI was lower in pigs fed MOS ( $P < .06$ ) and CHL ( $P < .05$ ) in wk 1 and also during wk 2 ( $P < .05$ ) compared to CARB. Following ST challenge, CARB-fed pigs maintained an advantage in ADFI over the other treatments in wk 3 and 4 ( $P < .01$ ). In wk 1, G/F was greater ( $P < .05$ ) for CARB-fed pigs ( $.61 \pm .04$ ) than for CON ( $.49 \pm .04$ ), MOS ( $.49 \pm .04$ ) and CHL ( $.42 \pm .04$ ) treatments. During wk 3, immediately following ST, both CARB and CHL treatments had greater G/F than CON ( $P < .05$ ), and pigs fed MOS tended to have greater G/F compared to CON ( $P < .08$ ). We conclude that feeding MOS and CHL prior to ST may support improved gut function immediately following treatment as evidenced by improved G/F. However, neither additive enhanced growth relative to the complete absence of dietary antimicrobials, and neither was as effective as CARB in the weeks following ST.

**Key Words:** Carbadox, Sodium Chlorate, Mannanoligosaccharide

#### 150 Supplemental B-vitamins in pig nursery diets. T. Cline\*, S. Carter, G. Hill, S. Kim, A. Lewis, D. Mahan, H. Stein, and T. Veum, NCR-42 Swine Nutrition Committee.

Eight universities participated in a regional study to determine the efficacy of supplemental B-vitamins (BV) in starter diets. The basal phase 1 diet (fed for two weeks) contained corn, soybean meal, dried plasma, dried whey and lactose and was formulated to contain 1.5% lysine. The phase 2 diet (fed for three weeks) contained corn, soybean meal, dried blood cells and dried whey and was formulated to contain 1.3% lysine. A mixture of eight BV (niacin, riboflavin, pantothenic acid, B<sub>12</sub>, thiamin, biotin, folic acid and B<sub>6</sub>) was supplemented at levels of 0 (negative control), NRC suggested requirements for the 5 kg pig (X), 2X and 4X. A total of 760 pigs in 35 replications at the eight stations were fed their diets ad libitum in meal form. ADG, ADFI and G/F calculations were made for phase 1, phase 2 and for the overall period. There was a significant station effect ( $P < 0.01$ ) for all measurements, but the station x treatment interaction was not different for any criterion at any time period. ADG was not different among treatments during phase 1, but a quadratic effect ( $P < 0.01$ ) was observed during phase 2. Phase 1 and 2 means were 236, 250, 240 and 246 g/d and 478, 536, 534 and 525 g/d for the 0, X, 2X and 4X levels of BV, respectively. The quadratic effect was also significant ( $P < 0.01$ ) for the combined periods (381, 421, 417 and 413 g/d, respectively). Treatment had a minimal effect on feed intake with an unexplained cubic effect during phase 1 ( $P < 0.01$ ) but no statistical effect during phase 2 or overall. As with the gain data, G/F was not different in phase 1, but a quadratic ( $P < 0.01$ ) effect occurred in phase 2. Phase 1 and 2 G/F means were 768, 741, 754 and 765 g/kg and 575, 626, 626 and 612 g/kg for the 0, X, 2X and 4X levels, respectively. The combined data were also different (quadratic,  $P < 0.02$ ; 611, 647, 649, and 640 g/kg). We conclude that the NRC suggested requirement level of B-vitamins supplemented to nursery diets is adequate to maximize growth performance.

**Key Words:** Nursery, B-Vitamins, Pigs



**151 Response of weanling pigs to niacin and vitamin B<sub>12</sub> supplementation.** S.S. Blodgett\*, P.S. Miller, A.J. Lewis, and R.L. Fischer, *University of Nebraska, Lincoln*.

A 35-d experiment was conducted to assess the response of weanling pigs (n = 96) to supplemental niacin and vitamin B<sub>12</sub>. The purpose was to determine whether the niacin and vitamin B<sub>12</sub> requirements of nursery pigs are greater than the NRC (1998) recommendations for 5- to 10-kg pigs. Pigs (initial BW = 4.3 kg) were assigned to a 2 × 2 factorial arrangement of four diets: 1) no added niacin or vitamin B<sub>12</sub>; 2) 50 mg/kg added niacin; 3) 80 µg/kg added vitamin B<sub>12</sub>; and 4) 50 mg/kg added niacin and 80 µg/kg added vitamin B<sub>12</sub>. Pigs were housed in an environmentally controlled room (mean temperature = 25.5°C). Each pen contained three barrows and three gilts. The four treatments were replicated four times. Diets were in meal form and pigs had ad libitum access to feed and water throughout the experiment. Pigs were weighed weekly to determine ADG, ADFI, and ADG/ADFI. Pigs were visually scored to assess any niacin and vitamin B<sub>12</sub> deficiencies on d 14, 21, 28, and 35. No niacin × vitamin B<sub>12</sub> interactions were observed. During Phase I (d 0 to 14), supplemental niacin increased ADFI (P < 0.01); negative control = 307 g vs niacin = 329 g). During Phase II (d 15 to 35), supplemental vitamin B<sub>12</sub> increased ADG (P < 0.001; negative control = 441 g vs B<sub>12</sub> = 539 g) and ADFI (P < 0.01; negative control = 679 g vs B<sub>12</sub> = 818 g). For the entire 35-d period, supplemental vitamin B<sub>12</sub> increased ADG (P < 0.001; negative control = 348 g vs B<sub>12</sub> = 409 g), ADFI (P < 0.01; negative control = 525 g vs B<sub>12</sub> = 606 g), and ADG/ADFI (P < 0.05; negative control = 662 g vs B<sub>12</sub> = 675 g). There were no differences (P > 0.1) in vitamin deficiency symptoms among groups. Based on these results, supplemental niacin did not have an effect on growth performance, however vitamin B<sub>12</sub> supplementation increased growth performance of 5- to 10-kg pigs.

**Key Words:** Pigs, Nursery, Vitamin B Complex

**152 Evaluating the antioxidant status of the weaned pig from supplemental vitamin C and vitamin E.** S. Ching and D.C. Mahan\*, *The Ohio State University*.

Postweaning declines in serum α-tocopherol and Se, and their apparent inadequacy have been associated with the sudden deaths of pigs within a few weeks postweaning. Because ascorbic acid regenerates oxidized α-tocopherol and ascorbic acid synthesis increases during the early postweaning period, the antioxidant status of the pig may be compromised and be a contributing factor to the sudden death problem. A 2 × 2 × 2 factorial experiment, in a RCB design, conducted in 8 replicates evaluated the role of dietary vitamin E (0 vs 60 IU/kg), vitamin C (0 vs 1000 ppm) with fat (0 vs 5%) added to exacerbate the antioxidant problem in the weaned pig. A total of 232 crossbred pigs weaned at 19 d, weighing 6.7 kg BW were fed typical nursery diets for each of the 0-10 d, 10-24 d, and 24-38 d periods with the above nutrients added at the treatment levels indicated. Pigs on 4 replicates were bled at the end of each period with α-tocopherol, ascorbic acid, and triglyceride concentrations measured. During the 0-10 d period, ascorbic acid addition increased daily gains (152 vs 173 g/d; P < 0.01), vitamin E tended to increase gains (156 vs 170 g/d; P < .10), but there was no effect of dietary fat on daily gains. Gain:feed ratio was greater with added ascorbic acid (P < 0.01), vitamin E (P < 0.05), and fat (P < 0.05) during the Phase 1 period. During the Phase 2 and 3 periods there was no effect of ascorbic acid or vitamin E on pig performances, nor was there any interaction response. The addition of fat resulted in increased gain (P < 0.10), lowered feed intake (P < 0.05), improved gain:feed ratio (P < 0.01), and higher blood triglycerides (P < 0.01) for the last 2 periods. Serum ascorbate and α-tocopherol increased as the dietary levels of each increased (P < 0.01), but serum α-tocopherol tended to be higher (P < 0.10) only at 38 d postweaning when 1000 ppm ascorbic acid was fed. These results suggest that dietary vitamin C and vitamin E improved postweaning pig gain responses the initial 10 d postweaning, but there was no effect on serum α-tocopherol concentrations.

**Key Words:** Ascorbic Acid, α-Tocopherol, Pig

**153 Evaluating the influence of B vitamin supplementation on growth and carcass composition of growing and finishing swine.** B.V. Lawrence\*<sup>1</sup>, J.D. Hedges<sup>1</sup>, J.D. Hahn<sup>1</sup>, M.B. Coelho<sup>2</sup>, B.W. Cousins<sup>2</sup>, and S. Haye<sup>2</sup>, <sup>1</sup>Hubbard Feeds, Inc., <sup>2</sup>BASF Corporation.

An experiment was conducted with growing and finishing pigs (n=896; initial BW = 14.5 kg) to determine the effect of B vitamin (riboflavin,

pantothenic acid, niacin, folic acid and B12) fortification levels (NRC, 4X, 8X or 16X NRC) and gender (barrow or gilt) on growth and carcass composition. A commercial wean-finish facility was used. Pigs were housed in groups of 28 pigs/pen (4 pens/treatment/sex). At trial initiation, pigs were 47 days of age and had been fed a commercial nursery feed for 27 days. Experimental diets were corn-soybean meal based and did not contain supplemental fat. A six-phase feeding program was utilized and diets were fed ad libitum in meal form. Pen growth rate (834 vs. 789 g/day) was higher (P<.05) for the pigs fed the 8X NRC that resulted in an additional 5.4 kg of gain compared to pigs fed NRC B vitamin supplementation level. A sex X treatment interaction (P<.05) was detected with gilts demonstrating a more consistent weight gain response to B vitamin supplementation at day 109. Increasing B vitamin supplementation tended to increase (P<.10) empty body protein and fat-free total lean, which was greater for gilts than barrows. The potential gross income increase from feeding 8X NRC B vitamin fortification was \$2.00/pig in this study with a potentially greater advantage obtained by gilts over barrows. These results suggest that the B vitamin requirement of growing and finishing pigs may be greater than that suggested by NRC (1998).

**Key Words:** Swine, Vitamins, Performance

**154 Feeding high levels of natural or synthetic vitamin E to grower-finisher pigs.** N. D. Fastinger\*, T. G. Wiseman, and D. C. Mahan, *The Ohio State University*.

Feeding high dietary levels of vitamin E has not resulted in any toxic responses, but the levels fed may have been too low. Research has also suggested that natural vitamin E (RRR-α-tocopherol) may be more bioavailable than the synthetic (*all-rac*-α-tocopherol) form. Different tissue retentions may result and be dependant upon the form and level of the vitamin fed. This study evaluated the effects of the two forms of vitamin E (RRR- or *all-rac*-α-tocopherol) when provided at high dietary levels (0, 300, 900, and 2,700 IU/kg) on their potential toxicity and tissue retentions. Pig performance, tissue α-tocopherol, and blood-clotting time were the criteria evaluated. The experiment was a 2 X 4 factorial, in a RCB design conducted in three replicates using 5 pigs per pen. Animals were fed treatment diets from 25 to 110 kg BW. Samples of liver, loin, spleen, brain, lung, perirenal and subcutaneous fat were collected at 110 kg and analyzed for α-tocopherol. Blood-clotting time was performed at the end of the trial. Data were analyzed using the pen mean as the experimental unit. Daily gains and feed intakes were similar between 0 to 900 IU/kg, but reduced at the 2,700 IU level (P < 0.05) for both vitamin E forms. Tissue α-tocopherols were higher in the following order: subcutaneous fat > perirenal fat > liver > spleen > lung > brain > loin. Tissue α-tocopherol levels increased quadratically (P < 0.05) as both forms of vitamin E level increased. The form of vitamin E fed to the pigs did not result in different tissue concentrations of α-tocopherol when fed at ≤ 900 IU/kg, but at 2,700 IU level natural (RRR-α-tocopherol) vitamin E had higher (P < 0.05) tissue concentrations than the synthetic (*all-rac*-α-tocopherol) form. Blood-clotting time was similar when 0 to 900 IU/kg diet was fed, but increased at the 2,700 IU/kg level for both forms. These results suggest that either form of dietary vitamin E or levels ≤ 900 IU/kg diet had no adverse effect on grower finisher pig performance and that tissue levels of both forms of vitamin E increased as dietary levels increased.

**Key Words:** Vitamin E, Toxicity, Pigs

**155 Effects of removing vitamin and trace mineral premixes on growth and carcass measurements in finishing pigs housed in a moderately stressful environment.** C. W. Starkey\*, J. D. Hancock, J. S. Park, C. L. Jones, and J. D. Hancock, *Kansas State University, Manhattan*.

A total of 432 pigs were used in two experiments to determine the effects of omitting vitamin and trace mineral premixes (VTM) from diets of pigs in late and early finishing. The pigs were housed in moderately stressful housing conditions with crowding (2.03 m<sup>2</sup>/pig), large pens (3.7 m × 4.9 m), and maximum available variation in BW (20 kg to 25 kg between the lightest and heaviest pig in each pen). Treatments for Exp. 1 (late finishing) were corn-soy diets without or with vitamin and trace mineral premixes fed from 90 to 115 kg BW. No differences were observed for ADG (P > 0.18), ADFI (P > 0.48), gain/feed (P > 0.23), or within pen variation in final BW (P > 0.32) at completion of the growth assay. Upon slaughter, no differences were observed for HCW (P > 0.56), dressing percentage (P > 0.9), last rib backfat thickness

( $P > 0.13$ ), or vertebral breaks ( $P > 0.49$ ). For experiment two (early finishing to slaughter) treatments were corn-soy diets without or with vitamin and trace mineral premixes fed from 68 to 115 kg. There were no differences in ADG ( $P > 0.69$ ), ADFI ( $P > 0.85$ ), gain/feed ( $P > 0.7$ ), or within pen variation in final BW ( $P > 0.37$ ). Upon slaughter, there were no differences for HCW ( $P > 0.62$ ), dressing percentage ( $P > 0.98$ ), last rib backfat thickness ( $P > 0.58$ ), or vertebral breaks ( $P > 0.44$ ). In conclusion, deletion of vitamin and trace mineral premixes during finishing (68 to 115 kg) did not affect growth performance, within pen weight variation in BW at slaughter, carcass leanness, or integrity of vertebrae.

Item	Exp. 1			Exp. 2		
	Control	w/o VTM	SE	Control	w/o VTM	SE
ADG, kg	0.84	0.81	0.01	0.88	0.88	0.01
Gain/feed	0.299	0.289	0.007	0.292	0.292	0.007
Weight variation, kg <sup>a</sup>	6.2	6.5	0.5	5.9	6.3	0.4
Last rib backfat thickness, mm	23	24	0.3	20	20	0.7
No. of vertebral breaks/pig <sup>b</sup>	0.8	0.9	0.2	0.3	0.4	0.1

<sup>a</sup> Absolute values for deviation from the average slaughter weight within each pen. <sup>b</sup> Total number of vertebral separations on both sides of the split carcass.

**Key Words:** Pigs, Vitamins, Trace Minerals

**156 Acidulated soapstock and restaurant grease in diets for finishing pigs.** C. W. Starkey\*, J. D. Hancock, D. H. Kropf, C. L. Jones, K. H. Hachmeister, and J. D. Dunn, *Kansas State University, Manhattan*.

A total of 360 pigs were used in a 70-d growth assay to determine the effects of adding acidulated soybean oil soapstock and restaurant grease to diets for finishing pigs. Treatments were: 1) corn-soy-based control with no added fat; 2) soybean oil; 3) acidulated soapstock; 4) choice white grease; and 5) restaurant grease. All fat sources were added at 6% of the diet. For d 0 to 35 and overall (d 0 to 70), diets with added fat supported greater ADG ( $P < 0.05$ ) and gain/feed ( $P < 0.001$ ) compared to the control diet without added fat. However, there were no differences in growth performance among pigs fed the various fat sources ( $P > 0.3$ ). No differences were observed for HCW or dressing percentage among pigs fed the various treatments ( $P > 0.08$ ), but pigs consuming diets with added fat had greater last rib backfat thickness ( $P < 0.001$ ) and lower fat free lean index ( $P < 0.001$ ). Belly firmness was greater for pigs fed the control treatment ( $P < 0.001$ ) compared to pigs fed diets with added fat. Also, pigs consuming diets with fat of plant origin (soybean oil and soapstock) had softer bellies ( $P < 0.001$ ) compared to pigs consuming animal fats (choice white grease and restaurant grease). In conclusion, adding fat to diets for finishing pigs improved growth performance with no differences among pigs fed the various fat sources. Plant oils resulted in softer bellies than animal fats, but responses in pigs fed diets with soy oil soapstock and restaurant grease were comparable to those in pigs fed diets with soy oil and choice white grease. Soy oil soapstock and restaurant grease are economically attractive fat sources for use in diets of finishing pigs.

Item	Control	Choice				SE
		Soy oil	Soapstock	white grease	Restaurant grease	
ADG, kg	0.90	0.92	0.94	0.93	0.93	0.03
Gain/feed	0.352	0.386	0.387	0.385	0.384	0.009
Last rib backfat thickness, mm	22	24	24	24	24	1
Belly firmness, <sup>a</sup>	5.9	3.5	3.4	5.1	5.2	0.2

<sup>a</sup> Scored on a scale of 1 to 9

**Key Words:** Pigs, Restaurant Grease, Acidulated Soapstock

**157 The influence of tylosin or rotational antibiotic use on apparent ileal and total tract digestion by growing pigs.** M. R. Smiricky\*, D. M. Albin, J. E. Wubben, V. M. Gabert, C. T. Collier, and H. R. Gaskins, *University of Illinois*.

The extent to which the intestinal microbiota and the inclusion of antibiotics in the diet affect the nutritional efficiency of the pig is not clear. Therefore, the objective of this study was to determine the influence of continuous tylosin, rotational antibiotic, or no antibiotic supplementation to the diet on apparent ileal and total tract digestion by growing pigs. 15 pigs (avg. initial BW = 15 kg) were surgically fitted with a prececal simple-T cannula. Pigs were fed a corn-soybean meal-based diet containing no antibiotics for 14 d post-surgery. On d 14, pigs were randomly allotted to 3 dietary treatments, a continuous tylosin (CT) diet, a rotational antibiotic (RA) diet, or a control diet containing no antibiotics. The experimental diets were formulated to contain 21% CP. Chromic oxide (0.3%) was added as an indigestible marker for determination of nutrient digestibilities. The antibiotics were added to the control diet at the expense of cornstarch. The CT diet contained 44.2 mg tylosin/kg diet and the RA diet sequence was CSP (276.3 mg/kg diet), bacitracin (33.2 mg/kg)-roxarsone (37.6 mg/kg diet), lincomycin (22.1 mg/kg diet), carbadox (27.6 mg/kg diet), and virginiamycin (11.1 mg/kg diet). Pigs were fed 0.76, 0.92, 1.08, 1.24, 1.36, and 1.52 kg/d for periods 1-6, respectively, in 2 equal feedings at 0800 and 2000 h. The experimental period lasted 7 d, with 5 d of diet adaptation, fecal collection on d 6, and ileal digesta collection on d 7. Diets, feces, and digesta samples were analyzed for DM, OM, CP, AA, and chromic oxide concentrations. Continuous tylosin consumption improved ( $P < 0.07$ ) apparent ileal and total tract Ile, Lys, Thr, and Val digestibilities. Apparent ileal digestibility of Arg and Met, and total tract digestibility of DM and His, tended to improve ( $P < 0.15$ ) by continuous tylosin supplementation. The RA diet improved ( $P < 0.05$ ) apparent ileal and total tract digestibilities of DM, OM, N, Arg, His, Ile, Leu, Lys, Met, Phe, Thr, and Val when compared to the control diet. In conclusion, both continuous tylosin and this rotational antibiotic sequence improved apparent ileal and total tract nutrient digestion by the growing pig.

**Key Words:** Pigs, Antibiotics, Digestibility

**158 Efficacy of betaine in diets for uncrowded and crowded finishing pigs.** L. A. Pettey\*, G. L. Cromwell, M. D. Lindemann, H. J. Monegue, R. D. Coffey, G. R. Parker, and K. M. Laurent, *University of Kentucky, Lexington*.

Betaine addition to diets has been shown to spare energy. A study was conducted to determine if betaine would overcome the depression in growth observed when pigs are crowded and unable to consume adequate feed (energy). Treatments were arranged as a 2 x 3 factorial with three replications to assess betaine at three degrees of crowding. Crossbred pigs (n=126) averaging 33 kg BW were allotted to pens (4.97 m<sup>2</sup>/pen) in a temperature-controlled, partially slotted floor building in groups of five, seven, or nine pigs/pen, resulting in 0.99, 0.71, and 0.55 m<sup>2</sup>/pig. Each pen had a two-hole feeder. Corn-soy diets containing 0.90, 0.80, and 0.65% lysine were fed during three phases with lysine reduced at 55 and 86 kg BW. Diets were a control or betaine added at 1.14 g/kg (0.125% Betafin<sup>®</sup>; Finnfeeds Intl., Ltd, Marlborough, U.K.). The experiment was conducted from December to April and the mean temperature in the building was 16.8°C. All pigs were scanned by real-time ultrasound at termination (116 kg mean BW). Growth rate and feed intake decreased linearly ( $P < 0.001$ ) with increased crowding (881, 855, 809 g/d; 2,606, 2,495, 2,391 g/d) but feed:gain was unaffected (2.96, 2.92, 2.96). Scanned 10th rib backfat, loin eye area, and percent fat-free lean (adjusted for final BW) tended to improve in crowded pigs due to reduced energy intake (22.8, 22.6, 20.9 mm; 39.3, 39.8, 41.4 cm<sup>2</sup>; 50.3, 50.5, 51.8%), but fat-free lean gain decreased linearly ( $P < 0.01$ ) with crowding (338, 329, 319 g/d). Betaine had no effect on gain (858 vs 839 g/d for control vs betaine), feed intake (2,519 vs 2,475 g/d), feed:gain (2.93 vs 2.95), backfat (22.1 vs 22.1 mm), fat-free lean (51.1 vs 50.7%), or lean gain (335 vs 323 g/d), but it reduced loin eye area (41.0 vs 39.4 cm<sup>2</sup>,  $P < 0.03$ ). Response to betaine was similar in uncrowded and crowded pigs as evidenced by a non-significant betaine x crowding interaction ( $P > 0.25$ ) for all traits except loin eye area. In this study, the effects of betaine did not overcome the negative growth effects of crowding in finishing pigs.

**Key Words:** Pigs, Betaine, Crowding

**159 Effect of oral glycerol administration with and without dietary betaine on carcass composition and meat quality of late-finishing barrows.** J.C. Airhart\*, T.D. Bidner, and L.L. Southern, *LSU Agricultural Center, Baton Rouge.*

An experiment was conducted to determine the effects of oral glycerol administration with and without dietary betaine on carcass composition and meat quality in late-finishing barrows. Crossbred barrows (initial and final BW of 96 and 111 kg) were allotted to four treatments: 1) corn-soybean meal (C-SBM) diet, 2) C-SBM + 0.25% dietary betaine, 3) C-SBM + oral glycerol (1g/kg BW), or 4) C-SBM + 0.25% betaine + glycerol (1g/kg BW). Each treatment was replicated with six barrows penned individually in 1.1 X 3.7 m pens with solid concrete floors. Dietary betaine was provided in the diets for 20 d before slaughter. Feed and water were provided on an ad libitum basis. Diets were formulated to provide 0.60% total Lys and met or exceeded all other nutrient requirements for finishing pigs. The glycerol was administered orally at 24 h and 3 h before slaughter at the rate of 1 g/kg BW each time. Daily gain, ADFI, and gain:feed were not affected ( $P > 0.10$ ) by betaine during the feeding period. At slaughter, plasma urea N concentrations were decreased ( $P < 0.01$ ) by dietary betaine but not affected ( $P > 0.10$ ) by oral glycerol administration. Plasma lactate was not affected ( $P > 0.10$ ) by treatment. Tenth rib fat thickness, loin muscle area, dressing percentage, fat-free lean, percentage lean, objective color, shear force, 45-min and 24-h pH, and purge loss were not affected by treatment. Loin muscle drip and total losses were increased ( $P < 0.10$ ) by dietary betaine. Although the effects were not significant, glycerol administration tended to decrease drip, cook, and total losses.

**Key Words:** Glycerol, Betaine, Pigs

**160 Effect of dietary manipulation of the starter feeding program on subsequent performance and carcass characteristics of finishing pigs.** A.M. Gaines\*, G.L. Allee, J.W. Frank, D.C. Kendall, J.D. Spencer, and G.F. Yi, *University of Missouri-Columbia.*

A trial using 240 weanling pigs (EB x Genepacker 34) was conducted to determine the effects of the starter feeding program on the subsequent performance and carcass characteristics of finishing pigs. Pigs (15 d and 4.9 kg) were weaned into a SEW facility and given free access to a complex diet for seven days postweaning. At 7 d postweaning, pigs (barrows and gilts) were weighed and allocated to one of three dietary treatments (Trt) in a randomized complete block design with 10 replications/Sex/Trt (60 pens). Trt included a complex diet (CS), a simple diet (SS) with no specialty ingredients, or a low protein complex diet (LP) with dietary protein reduced 20%. Pigs were fed in two dietary phases (P1: 7-21 d; and P2: 21-42 d). Performance parameters of ADG, ADFI, and G:F were measured. At 42 d, pigs were moved to an off-site finishing facility to evaluate subsequent performance and carcass characteristics with 5 replicate pens/Sex/Trt (30 pens). Pigs were fed fortified corn-soybean meal diets in four dietary phases with sexes fed separately. Performance parameters of ADG, ADFI, and G:F were measured. Real time ultrasound was used to determine 10th rib backfat (BF) and loin-eye area (LEA). Initial weights ( $6.68 \pm 0.02$  kg) at 7 d did not differ among Trt ( $P > 0.41$ ) or between sexes ( $P > .15$ ). At the end of the nursery phase (42 d), there was a Trt effect for BW, ADG, and G:F with pigs fed CS and SS pigs being heavier ( $P < 0.01$ ), gaining faster ( $P < 0.01$ ) and more efficiently ( $P < 0.01$ ) than LP pigs. The BW at 42 d for the CS, SS, and LP pigs were 26.3, 26.4, and 24.4 kg, respectively. For the overall finishing period (42-142 d), there were no Trt differences for pig performance, with the BW at 142 d for pigs from CS, SS, and LP being 111.9, 113.6, and 110.7 kg, respectively. Initial ultrasound measurements (42 d) showed LP pigs to have increased BF depths ( $P < 0.01$ ) and less lean ( $P < 0.01$ ) compared to CS and SS pigs. However, no Trt differences were observed at the end of the finishing period. This study suggests that early short-term restriction of growth due to a 20% restriction of protein does not affect subsequent performance or carcass characteristics and that simple diets during the starter period may have a place in high-health operations.

**Key Words:** Pigs, Starter Diets, Performance

**161 Evaluating phase feeding of gilts and barrows during the grower-finisher period.** D.C. Mahan\*, S.D. Carter, T.R. Cline, G.L. Cromwell, G.M. Hill, and G.R. Hollis, *NCR-42 Committee.*

The dietary protein (lysine) requirement declines as the pig progresses toward market weight, suggesting that properly formulated diets at various phases would result in greater efficiencies. NCR-42 Swine Nutrition Committee members from 6 stations (IL, IN, KY, MI, OH, OK) evaluated this concept using 649 crossbred pigs in a  $2 \times 5$  factorial, RCB design in 14 replicates. Gilts and barrows were fed C-SBM mixtures with 1, 2, 3, 4, or 5 dietary lysine levels from 23 to 115 kg BW. Diets were calculated to meet the average lysine requirement for the single phase and for each dietary phase. Dietary lysine (total) for gilts fed the 5 sequences were: 1) 0.88; 2) 1.03, 0.75; 3) 1.17, 0.88, 0.60; 4) 1.17, 0.98, 0.78, 0.60; and 5) 1.17, 1.03, 0.88, 0.75, 0.60%. Barrows were fed similar sequences, but lysine levels were lower by 0.15% for each phase, respectively. Diets were changed at equally spaced intervals within each treatment group. Carcass or real-time measurements were collected at the trials' end. Daily gains (881, 892, 852, 863, 854 g) declined ( $P < 0.01$ ) as the no. of dietary sequences increased. Barrows gained faster and were less efficient than gilts ( $P < 0.01$ ), with responses to dietary sequences similar for each gender. Days to 115 kg were greater as the no. of dietary changes increased ( $P < 0.05$ ); gilts averaged 3.8 d longer on test ( $P < .01$ ) than barrows. Average daily lysine intake declined (20.9, 20.1, 19.4, 19.4, 19.0 g/d) as the no. of diet changes increased ( $P < 0.01$ ); gilts had higher lysine intakes (20.6 vs 18.9 g/d;  $P < 0.01$ ) than barrows. Carcass measurements were influenced ( $P < 0.05$ ) by dietary sequence, particularly the loin eye area and fat-free lean gain (335, 337, 323, 325, 324 g/d) as dietary sequence increased. Gilt fat-free lean averaged 337 and barrows 320 g/d. These results suggest that growing-finishing pig performances and carcass characteristics were not improved by providing several dietary sequences, and that inadequate lysine during the finisher period may have caused the lowered performances of the latter groups.

**Key Words:** Grow-Finish, Lysine, Pig

**162 Effect of wheat middlings, enzyme supplement, and dietary lysine level on growing-finishing pig performance, carcass measurements, and amino acid digestibility.** J.C. Peters\*, D.C. Mahan, N.D. Fastinger, and T.G. Wiseman, *The Ohio State University.*

Wheat middlings are frequently used in grower-finisher diets but the fiber fraction is considered poorly digested. Previous attempts to add enzymes to wheat middling diets have been inconsistent. An experiment evaluated the effects of wheat middlings and an enzyme supplement fed to grower-finisher pigs on pig performance and carcass measurements. Normal and low lysine levels were fed to better evaluate if supplemental enzymes improved performance. A  $2 \times 2 \times 2$  factorial, in a RCB design used 336 crossbred pigs in 6 replicates. Corn-soy diets contained wheat middlings (0, 20%), a combination of protease and xylanase enzymes (Vegpro) at 0 or 10%, and 2 lysine levels (NRC, NRC minus 0.1% lysine). Treatment diets were fed from 27 to 107 kg BW. The middlings did not affect average daily gain (877 vs 869 g/d), but feed intake was higher ( $P < 0.01$ ) only between 80 and 107 kg BW. Daily gains were lower (903 vs 843 g/d;  $P < 0.01$ ) when the lower lysine level was fed, with no interaction between lysine level and enzyme supplement. Backfat thickness decreased ( $P < 0.01$ ) when wheat middlings were fed, but loin muscle area and lean gain increased ( $P < 0.05$ ). An interaction between wheat middlings and added enzymes resulted in improved fat-free lean gain ( $P < 0.05$ ) when middlings were fed. Enzyme addition did not affect ( $P > 0.15$ ) growth performance or carcass measurements. A second  $2 \times 2$  factorial experiment in a RCB design (5 reps), evaluated the effects of enzyme supplementation (0, 0.10%) and wheat middlings (0, 20%) on amino acid and energy digestibility. Amino acid digestibility ( $P < 0.01$ ) and digestible energy were both lower ( $P < 0.05$ ) with added wheat middlings. Enzyme addition did not affect amino acid digestibility ( $P > 0.10$ ), but digestible energy was improved ( $P < 0.05$ ). These results suggest that feeding 20% wheat middlings did not decrease pig gain but increased carcass lean. Enzyme addition seemed to improve digestible energy but not animal performance.

**Key Words:** Pigs, Enzyme, Lysine

**163 Effect of dietary particle size and nutrient supply on nitrogen excretion of grower pigs.** M. A. Oryschak<sup>1,2</sup> and R. T. Zijlstra<sup>\*1</sup>, <sup>1</sup>Prairie Swine Centre Inc., <sup>2</sup>University of Saskatchewan, Saskatoon, Canada.

Nitrogen (N) output of the pork industry is a public concern. Previously, reducing dietary particle size reduced fecal N excretion, but increased urinary N excretion. In the present study, four diets (barley, soybean meal, peas; chromic oxide as marker) with two particle sizes (600 or 900  $\mu\text{m}$ ) and two nutrient supplies (DE-limiting: 2.8 g dig. Lys/Mcal DE, 3.15 Mcal DE/kg; or AA-limiting: 1.8 g dig. Lys/Mcal DE, 3.40 Mcal DE/kg) were used in a 2 x 2 factorial arrangement. Nine pigs (25  $\pm$  2 kg) had T-cannulas installed in the ileum; six observations were obtained per diet in three 12-d periods. Pigs were housed in individual metabolism pens, with restricted access to feed (3 x maintenance DE). Feed, feces, digesta, and urine were analyzed to determine apparent ileal and total-tract digestibility of N and energy, and total, fecal, and urinary N excretion. Particle size did not interact with nutrient supply for any variable ( $P > 0.10$ ). Reducing particle size from 900 to 600  $\mu\text{m}$  did not alter urinary or total N excretion ( $P > 0.10$ ), reduced fecal N excretion 11%, increased total-tract digestibility of N 3% and energy 3%, and increased ileal digestibility of N 9% and energy 11% ( $P < 0.05$ ). Particle size reduction may improve overall energy utilization more than explained by improvements in total-tract energy digestibility. Pigs fed DE-limiting diets excreted 29% more N, but also retained 31% more N than pigs fed AA-limiting diets ( $P < 0.05$ ). Total N excretion and N retention (as % N intake) were not different between nutrient supplies ( $P > 0.10$ ). For DE-limiting diets, energy did not limit N retention, because increased energy availability caused by particle size reduction did not increase N retention. In the present study, reducing particle size appeared to have a greater impact on efficiency of digestion for energy than N. Reducing particle size was effective in reducing fecal but not total N excretion; however, nutrient supply had a greater impact on N excretion.

**Key Words:** Particle Size, Nitrogen Excretion, Pig

**164 Development of an Isoleucine Deficient Diet in Growing and Finishing Pigs.** Brian Kerr<sup>\*1</sup>, T. M. Parr<sup>2</sup>, B. S. Borg<sup>3</sup>, J. M. Campbell<sup>3</sup>, K. L. Bryant<sup>4</sup>, and M. T. Kidd<sup>5</sup>, <sup>1</sup>USDA-ARS-SOMMRU, <sup>2</sup>University of Illinois, <sup>3</sup>American Protein Corporation, <sup>4</sup>Akey Incorporated, <sup>5</sup>Mississippi State University.

Two, 28 d trials were designed to define an isoleucine (Ile) deficient diet in growing (23 to 45 kg) and finishing (77 to 95 kg) pigs utilizing red blood cells (RBC) as a deficient Ile protein source. In trial 1, eight replications of four pigs/pen were fed a diet containing 4.2% RBC with or without crystalline (c) Ile, a diet containing 8.4% RBC with or without cIle, a low CP+AA control, or a high CP control. Diets were formulated to contain .90% digestible (d) lysine (dLys) with the unsupplemented 4.2% and 8.4% RBC diets formulated to a dIle:dLys ratio of .50 and .23, respectively. All other diets were formulated to a dIle:dLys ratio of .63. Average daily gain (ADG), average daily feed intake (ADFI) and gain:feed ratio (G:F) did not differ between pigs fed the high or low CP+AA diets ( $P > 0.05$ ). Utilization of 4.2% RBC had no effect on ADG or ADFI ( $P > 0.10$ ), but reduced G:F ( $P < 0.06$ ) which was alleviated by cIle supplementation. Utilization of 8.4% RBC reduced pig performance ( $P < 0.01$ ) and although performance was improved with cIle supplementation ( $P < 0.01$ ), performance remained lower than pigs fed the low CP+AA diet ( $P < 0.10$ ), but not pigs fed the high CP diet ( $P > 0.10$ ). In trial 2, six replications of four pigs/pen were fed a diet containing 2.9% RBC with or without cIle, a diet containing 5.8% RBC with or without cIle, a low CP+AA control, or a high CP control. Diets were formulated to contain .67% dLys with the unsupplemented 2.9% and 5.8% RBC diets formulated to a dIle:dLys ratio of .55 and .31, respectively. All other diets were formulated to a dIle:dLys ratio of .63. Performance did not differ between pigs fed the high or low CP+AA diets ( $P > 0.05$ ). Feeding 2.9% RBC, with or without cIle supplementation, had no effect on pig performance ( $P > 0.10$ ). Utilization of 5.8% RBC reduced pig performance ( $P < 0.01$ ), with cIle supplementation improving pig performance ( $P < 0.01$ ) to a level not different from pigs fed either control diet ( $P > 0.10$ ). Utilization of RBC offers a unique opportunity to evaluate Ile nutrition of growing and finishing swine.

**Key Words:** Isoleucine, Red Blood Cells

**165 Plasma urea nitrogen as an indicator of the isoleucine requirement of grower pigs.** T.M. Parr<sup>\*1</sup>, B.J. Kerr<sup>2</sup>, and D.H. Baker<sup>1</sup>, <sup>1</sup>University of Illinois, Urbana, IL, <sup>2</sup>Nutriquest, Inc., Chesterfield, MO.

Two trials were undertaken to verify the isoleucine (Ile) requirement of growing (25 to 45 kg) pigs. A previous growth trial in our laboratory had suggested a true digestible Ile requirement of between 0.44 and 0.47% of the diet. In the first study, a replicated 5 x 5 latin square design was used to determine the Ile requirement. Five barrows (square one) and five gilts (square two) were fed corn-red blood cell diets containing five graded increments of L-Ile to accomplish true digestible Ile levels of 0.35%, 0.39%, 0.43%, 0.47% and 0.51%. Pigs received each test diet for a period of 4 d, with blood being drawn at 0900 on the 5th d. Samples were analyzed for plasma urea nitrogen (PUN). Barrows had higher ( $P < 0.01$ ) PUN values than gilts, and PUN decreased linearly ( $P < 0.01$ ) in both sexes as Ile was incremented. The data suggested, however, an apparent plateau in both sexes at 0.47% digestible Ile. In the second trial, 100 pigs were assigned one of five diets formulated to test the pigs' response to Ile in the presence and absence of excess leucine (Leu) and valine (Val). The basal diet contained 0.38% true digestible Ile, with Leu and Val formulated to be just above the requirement, at 0.97 and 0.63%, respectively. Treatments were: 1) corn-soybean meal positive control, 2) Ile-deficient basal, 3) as 2 + 0.10% L-Ile, 4) as 2 + 1.0% L-Leu + 0.50% L-Val, and 5) as 2 + 0.10% L-Ile + 1.0% L-Leu + 0.50% L-Val. Pigs (26.0 kg initial body weight) were fed the experimental diets for 20 d, after which all pigs were bled for PUN assessment. Whether Ile-deficient (diets 2 and 4) or adequate (diets 3 and 5), excess Leu and Val depressed ( $P < 0.03$ ) both feed intake and weight gain, and tended to increase PUN. This suggested that excess Leu and Val may antagonize Ile when diets contain minimal levels of Ile. In conclusion, the true digestible Ile requirement of grower pigs appears to be in the range of 0.44 to 0.47%, which is in close agreement with the NRC (1998) estimate of 0.45%.

**Key Words:** Pig, Isoleucine, Plasma Urea Nitrogen

**166 Crystalline amino acid supplementation of grain sorghum-based, low protein diets for growing and finishing swine.** R. O. Myer<sup>\*</sup> and D. W. Gorbet, University of Florida.

Three trials were conducted to evaluate the effectiveness of crystalline lysine, threonine, methionine, and tryptophan supplementation of grain sorghum-based, low protein diets for G-F pigs. Each trial involved a comparison of grain sorghum-based diets formulated with 1) soybean meal (48%) as the supplemental source of amino acids (control) or 2) L-lysine HCl, L-threonine, DL-methionine, and L-tryptophan with enough soybean meal to meet the requirements of the other amino acids (AA). Amino acid supplementation reduced CP level of the diets by four percentage units. The trials were similar but conducted at different times and each utilized 60 crossbred pigs (5 reps) with avg initial weights of 35, 29, and 30 kg, respectively, for the three trials. For each trial, grower diets (.80% estimated digestible lys) were fed from 31 to 53 kg avg BW, finisher I (.68% dig lys) to 84 kg and finisher II (.55% dig lys) to 114 kg. The grain sorghum utilized was a blend of commercial, low tannin hybrids; a different crop of grain was used in each trial. At the end of the trials, all pigs were scanned to estimate carcass lean content. Overall results over the three trials for the control and AA treatments, respectively, were: 1.01 and .99 kg ADG ( $P > .10$ ; SE = .01), 2.69 and 2.67 kg ADF ( $P > .10$ ; SE = .03), 2.68 and 2.69 F/G ( $P > .10$ ; SE = .02), 51.0 and 50.6% estimated carcass lean ( $P > .10$ ; SE = .3), and .383 and .374 kg avg lean gain/d ( $P = .09$ ; SE = .003). There was no grain crop (trial) x diet effects ( $P > .10$ ). Results indicated that upon supplementation with crystalline lysine, threonine, methionine, and tryptophan, the protein level of grain sorghum based diets can be reduced by four percentage units with very little or no effect on growth performance or carcass lean yield of growing and finishing pigs.

**Key Words:** Pigs, Amino Acids, Grain Sorghum

**167 Differences in apparent and standardized crude protein and amino acid digestibility coefficients among low phytate corn, normal corn, and soybean meal in growing pigs.** R. A. Bohlke\*, H. H. Stein, A. R. Wirt, and R. C. Thaler, *South Dakota State University*.

Nine crossbred growing barrows (BW=29.3 ± 1 kg) were fitted with T-cannulas in the distal ileum to determine crude protein (CP) and amino acid (AA) digestibility coefficients of low phytate corn (LPC), normal corn (NC), and soybean meal (SBM). Three diets containing either LPC, NC, or SBM as the sole source of CP and AA were formulated, as was a nitrogen-free diet (N-free). Chromium oxide was included in each diet as an inert marker. Each diet was fed to the pigs for nine days with digesta being collected from 0800 to 2000 on d 8 and d 9. At the end of the experiment, apparent (AID) and standardized ileal CP and AA digestibility coefficients (SID) were calculated for each ingredient. The AID for CP and all indispensable AA except leucine (Leu) and methionine (Met) were higher ( $P < 0.05$ ) for SBM compared to NC and LPC. The AID of arginine (Arg), lysine (Lys), and valine (Val) were higher ( $P < 0.05$ ) in LPC than in NC, but no differences ( $P > 0.05$ ) were found for CP and the other indispensable AA. The SID were calculated by correcting the AID for the endogenous losses of CP and AA determined after feeding the N-free diet. The SID of isoleucine (Ile), Lys, phenylalanine (Phe), and threonine (Thr) were higher ( $P < 0.05$ ) in LPC than in NC. Likewise, a tendency for higher ( $P < 0.07$ ) SID in LPC than in NC was observed for CP, and Val, while no differences ( $P > 0.05$ ) were observed for the remaining indispensable AA. The SID for CP, Thr, Lys, histidine (His), Arg, Ile, and tryptophan (Trp) were higher ( $P < 0.05$ ) in SBM than in NC, but when comparing SBM to LPC, differences ( $P < 0.05$ ) were found only for Lys and His. In conclusion, the results of the current experiment demonstrate that both apparent and standardized ileal AA digestibility coefficients are at least as high in LPC as they are in NC.

**Key Words:** Pigs, Digestibility, Amino Acids

**168 Determining an optimum lysine:calorie ratio for 35 to 60 kg gilts in a commercial finishing facility.** R.G. Main\*, S.S. Dritz, M.D. Tokach, R.D. Goodband, and J.L. Nelssen, *Kansas State University, Manhattan, Kansas*.

Our objective was to determine the optimum lysine:calorie ratio (g total dietary lysine/Mcal of ME) for gilts (48 kg midpoint; PIC L337 # C22) in a commercial finishing environment. Forty-two pens (1,176 pigs; initially 35.1 ± .16 kg) were used in a randomized complete block design. Treatments included feeding six lysine:calorie ratios (2.55, 2.89, 3.23, 3.57, 3.91, and 4.25 g lysine / Mcal of ME) for a 28 day feeding period. There were 28 pigs per pen and 7 pens per treatment. All diets were corn-soybean meal based with 6% choice white grease. Dietary lysine:calorie ratios were attained by adjusting the corn:soybean meal inclusion rates, and no crystalline lysine was used to ensure lysine was first limiting. Five pigs per pen were individually weighed and scanned with ultrasound on d 0 and 28 as used to measure tenth rib fat depth and loin eye area. Quadratic improvements were observed ( $P \leq 0.04$ ) for pigs fed increasing levels of total dietary lysine (0.91, 1.04, 1.16, 1.28, 1.40, or 1.52 %) for daily gain (895, 909, 930, 907, 905, 890 ± 12 g/day) and feed efficiency (G:F; 0.46, 0.47, 0.48, 0.47, 0.48, 0.47 ± 0.006). Tenth rib fat depth on d 28 (8.4, 8.8, 8.4, 8.4, 8.0, 7.7 ± 0.26 mm) and change in fat depth (2.5, 2.5, 2.3, 2.1, 1.9, 1.5 ± .18 mm) were linearly decreased ( $P \leq .01$ ) as dietary lysine increased. Loin eye area measurements were not ( $P \geq .36$ ) affected by dietary treatment. Economic analysis indicated that gilts fed the lowest dietary lysine level had the lowest feed cost per unit of gain. However, margin over feed cost responded in a quadratic manner with the greatest return for gilts fed 3.23 g lysine/ Mcal of ME. These data indicate that gilts from 35 to 60 kg required 3.23 g of lysine / Mcal of ME (1.16 % total dietary lysine, 3,578 kcal/kg diet) for maximal growth rate, feed efficiency, and marginal return.

**Key Words:** Lysine, Requirement, Finishing

**169 Effects of pharmacological concentrations of zinc oxide and phytase on zinc excretion and performance in the nursery pig.** M.M. Martinez\*, G.M. Hill, J.E. Link, J.G. Greene, and D.D. Driksna, *Michigan State University, East Lansing, MI*.

The benefits of feeding pharmacological concentrations of zinc (Zn) as oxide (ZnO) in the first 14 d post-weaning are well documented. However, the effects pharmacological dietary concentrations have on excreted minerals is an environmental concern. Exogenous phytase in pig diets results in an increase of P and Zn retention. The objective of this experiment was to evaluate the effects of three concentrations of Zn (150 ppm, 1,000 ppm or 2,000 ppm as ZnO) with and without the addition of phytase (500 PTU/kg of Natuphos<sup>TM</sup>) on Zn excretion and performance of nursery pigs. Twenty-four crossbred barrows (7.1 kg and 22 d of age) were placed in individual stainless steel metabolism crates for a 21 d balance study. Pigs were fed 2 phase experimental diets from d 1-7 and d 8-14. During d 15-21 the animals were fed a common diet, which had adequate Zn (150 ppm) and no added phytase. Urine, feces and orts were collected twice a day and pigs were weighed weekly. Growth performance (ADG, ADFI or G:F) did not differ among treatments. In the first period of the study (d 2-7), fecal Zn concentrations from pigs fed 2,000 ppm Zn ranged from 63.4 mg/d to 337.6 mg/d and were 14 times greater ( $P < 0.01$ ) than the fecal Zn concentrations of animals fed 150 ppm Zn (11.8 mg/d to 17.9 mg/d). During the second period (d 8-14) the range of Zn fecal excretion of pigs fed 2,000 ppm Zn, decreased from 347.0 mg/d to 277.0 mg/d and plateaued. The amount of Zn excreted was 30 times greater ( $P < 0.01$ ) than that excreted when pigs were fed 150 ppm. During the last period (d 15-21), all the pigs excreted comparable amounts of Zn. Animals fed 2,000 ppm Zn for growth promotion excreted approximately 203.1 mg/d of Zn during the 14 d post-weaning period. Pigs fed 150 ppm Zn were in neutral balance during the 21 d study and did not differ from those pigs fed 1,000 ppm Zn. Barrows fed 2,000 ppm Zn were in a positive balance from d 1-14, but were in a negative balance from d 15-21 when dietary Zn was reduced to 150 ppm.

**Key Words:** Zinc, Phytase, Nursery Pig

**170 Effects of the addition of phytase and pharmacological concentrations of zinc oxide on phosphorus excretion in the nursery pig.** M.M. Martínez\*, G.M. Hill, J.E. Link, J.G. Greene, and D.D. Driksna, *Michigan State University, East Lansing, MI*.

Around 80% of the phosphorus (P) found in cereal grain diets is bound to phytate, which is unavailable to non-ruminants leading to higher mineral excretion and environmental concerns. Furthermore, many post-weaning swine diets contain pharmacological concentrations of zinc oxide (ZnO) for growth enhancement. Exogenous phytase increases mineral availability for absorption. The objective of this 3 x 2 factorial study was to determine the effects of adequate and pharmacological Zn (150 ppm, 1,000 ppm and 2,000 ppm) and phytase (0, 500 PTU/kg of Natuphos<sup>TM</sup>) on P excretion. Twenty-four crossbred barrows (7.1 kg and 22 d of age) were placed in individual metabolism cages for a 21 d mineral balance study. Pigs were fed 2 phase experimental diets twice a day for d 1-7 and d 8-14. During d 15-21 the animals were fed a common diet, which had adequate Zn (150 ppm) and did not contain phytase. Urine, feces and orts were collected twice a day. Concentrations of P were determined by a colorimetric method of Gomorri (1942). Pigs fed phytase supplemented diets had 1.2 times lower ( $P < 0.0001$ ) fecal P (15.1 mg/d vs 17.7 mg/d), and 1.5 times greater ( $P < 0.05$ ) urinary P (0.00038 mg/d vs 0.00023 mg/d) than non-supplemented diets. Pharmacological Zn supplementation had no effect on fecal P concentrations ( $P > 0.05$ ). Barrows fed 2,000 ppm Zn plus phytase had a more positive P balance (2193.3 mg/d;  $P < 0.04$ ) when compared to 2,000 ppm Zn without phytase (1820.1 mg/d). This effect was not seen with the other Zn treatments. Regardless of dietary treatment, P balance was positive throughout the 21 d of the study. In conclusion, the addition of phytase to nursery diets has a beneficial effect on reducing fecal, but not urinary concentrations of P. This practice could be incorporated into dietary formulation of nursery pig diets to reduce P loading of soils.

**Key Words:** Phosphorus, Phytase, Nursery Pig

**171 Effect of phytase dosage and source on growth performance of nursery pigs.** B. W. James<sup>\*1</sup>, M. D. Tokach<sup>1</sup>, R. D. Goodband<sup>1</sup>, J. L. Nelssen<sup>1</sup>, S. S. Dritz<sup>1</sup>, and G. L. Lynch<sup>2</sup>, <sup>1</sup>Kansas State University, Manhattan, <sup>2</sup>BASF Corporation, Mount Olive, NJ.

A 28-d growth assay was conducted to determine the effect of phytase dosage and source on growth performance of nursery pigs. A total of 342 pigs (initially 11.0 kg, PIC C22 × 326) were blocked by weight and allotted randomly to nine dietary treatments. Each treatment had eight replications and four or five pigs per pen. The basal diet was corn-soybean meal based and was formulated to contain 5% added fat, 1.4% total lysine, and 0.13% available P. Monocalcium phosphate was substituted for sand to form the other control diets (0.18 and 0.23% available P). Phytase (100, 225, or 350 FTU or FYT/kg) from either Natuphos<sup>®</sup> or Ronozyme<sup>™</sup> P was added to the 0.13% available P diet at the expense of sand. Calcium to total P ratio was maintained at 1.12:1 in all diets. All ingredients were analyzed for phosphorus before diet formulation and analyzed diet values agreed with formulated values. Increasing available P linearly ( $P < 0.01$ ) improved ADG and feed efficiency. There were no phytase source × level interactions ( $P > 0.23$ ) or differences between phytase sources ( $P > 0.27$ ). Increasing phytase level linearly ( $P < 0.01$ ) increased ADG and feed efficiency. Regression analysis of the ADG response indicated that, when adding less than 350 phytase units/kg, each 100 phytase units/kg will release 0.022 and 0.017% available P for Natuphos<sup>®</sup> and Ronozyme<sup>™</sup> P, respectively.

	Available P, %			Ronozyme, FYT/kg			Natuphos, FTU/kg		
	0.13	0.18	0.23	100	225	350	100	225	350
ADG, g	602	650	694	623	642	659	624	669	667
Gain/feed	0.639	0.655	0.673	0.668	0.663	0.673	0.650	0.655	0.680

**Key Words:** Phytase, Phosphorus, Nursery Pigs

**172 Response of barrows to phytase in pelleted diets.** M. C. Brumm<sup>\*1</sup>, <sup>1</sup>University of Nebraska.

Crossbred barrows (n=288, 20.5 kg BW) were used to evaluate pre-pelleting additions of 2 phytase sources in diets fed to slaughter weight (111.8 kg BW). There were 4 pens of 12 pigs/pen/treatment. Treatments were: 1) control formulated to University of Nebraska (UNL) recommendations for available P (0.29%, 20-36 kg BW; 0.22%, 36-59 kg BW; 0.19%, 59-86 kg BW; and 0.16%, 86 kg to market), 2) UNL formulated to 0.1% lower available P (NEG), 3) Ronozyme P CT (R) added to NEG at 500 FYT/kg (R500), 4) R added to NEG at 750 FYT/kg (R750), 5) Natuphos 10000G (N) added to NEG at 500 FTU/kg (N500) and 6) N added to NEG at 750 FTU/kg (N750). All diets contained 10% wheat midds with a pellet exit temperature of 65.5 to 71.1<sup>o</sup> C. Contrasts to separate treatment means were: 1) UNL vs NEG, 2) UNL vs 500 phytase (FYT or FTU) units, 3) UNL vs 750 phytase units, 4) 500 versus 750 phytase units and 5) R versus N. Compared to UNL, pigs fed NEG had decreased daily gain (809 vs 886 g/d,  $P < 0.01$ ), decreased daily feed (2.32 vs 2.46 kg/d,  $P < 0.05$ ) and gain:feed (0.351 vs 0.364,  $P < 0.05$ ). Similar responses were observed ( $P > 0.2$ ) when comparing 500 or 750 phytase units to UNL on daily gain, daily feed, gain:feed, carcass lean and daily lean gain. There was no difference ( $P > 0.2$ ) between 500 vs 750 phytase units on daily gain, daily feed, gain:feed or carcass lean percentage. There was no effect ( $P > 0.2$ ) of R vs N on daily gain or daily feed (2.43 vs 2.49 kg/d). However, the numeric difference in gain and feed resulted in a difference in gain:feed for R vs N (0.360 vs 0.352,  $P < 0.05$ ). Feeding NEG diets resulted in a decrease ( $P < 0.01$ ) in bone ash (59.5 vs 61.5%) and bone breaking strength (186 vs 244 kg) versus UNL. While bone ash decreased ( $P < 0.1$ ) going from 500 to 750 phytase units (61.2% vs 60.4%), there was no effect ( $P > 0.2$ ) of phytase level on bone breaking strength (230 vs 240 kg). There was no difference ( $P > 0.2$ ) in R vs N for bone ash or breaking strength. Phytase from either source added prior to pelleting was effective in preventing the decrease in performance associated with diets formulated to contain 0.1% lower available P than current UNL recommendations.

**Key Words:** Pigs, Phosphorus, Phytase

**173 Phytase additions to conventional and low-phytate corn for pigs.** E. G. Xavier<sup>\*</sup>, G. L. Cromwell, and M. D. Lindemann, University of Kentucky.

Two experiments were conducted to assess the efficacy of phytase (Natuphos<sup>®</sup>, 600 units/kg) addition on bioavailability of P in corn and corn-soybean meal (SBM) for growing pigs. In Exp. 1, a low P (0.11%), phytate-free basal diet (1.2% lysine, 0.8% Ca) consisted of casein (15%), dextrose-sucrose (1:1), and supplemental AA, minerals (except P), and vitamins. In Diets 2 and 3, monosodium phosphate (MSP) provided 0.10 and 0.20% added P. Diet 4 was a 3:1 blend of corn and SBM substituted for the sugars to provide 0.27% added P. Diet 5 was as Diet 4 with phytase. Diets 6 and 7 included phytase addition to Diets 1 and 3. Each diet was fed to four individually penned pigs for 28 d, from 12 to 28 kg. Breaking strength of metatarsals, metacarpals and femurs were regressed on added P intake and single-point, slope-ratio procedures were used to assess P bioavailability in the corn-SBM mix. Bone responses in Diets 1-3 were linear ( $P < 0.001$ ) with a good fit ( $r^2 = 0.99$ ). Gain and relative bone strength of pigs fed Diets 1-7 were: 436, 519, 580, 588, 730, 413, 613 g/d; 100, 199, 301, 159, 328, 95, 285 (both  $P < 0.01$ ), respectively. Bioavailability of P increased from 24% in the corn-SBM diet to 79% when phytase was added. In Exp. 2, the efficacy of phytase was assessed in diets containing low-phytate (LP) corn or a near-isogenic, normal (N) corn. The N- and LP-corn contained 0.25 and 0.26% total P and 0.21 and 0.09% phytate P, respectively. Diets were the basal with (1) no added P, and 0.20% P added as (2) MSP, (3) N-corn, and (4) LP-corn. Diets 5 and 6 were as Diets 3 and 4, but with added phytase. Each diet was fed to six pigs (one/pen) for 28 d, from 11 to 27 kg. Gain and relative bone strength were: 584, 732, 653, 623, 623, 691 g/d; 100, 313, 143, 217, 253, 288 (both  $P < 0.01$ ). Bioavailability of P was estimated at 29 and 70% for the N- and LP-corn, and they increased to 91 and 103%, respectively, when phytase was added. The results indicate that phytase is efficacious when added to diets containing high- or low-phytate corn, but its efficacy is approximately twice as great in high- vs low-phytate diets.

**Key Words:** Pigs, Phosphorus, Phytase

**174 Effect of low phytate corn and dietary phytase addition on pig growth and fecal phosphorus excretion in a commercial environment.** G. Gourley<sup>\*1</sup>, T.E. Sauber<sup>2</sup>, D.B. Jones<sup>2</sup>, D. Kendall<sup>3</sup>, and G. Allee<sup>3</sup>, <sup>1</sup>Swine Graphics Enterprises, <sup>2</sup>Pioneer-A DuPont Company, <sup>3</sup>University of Missouri-Columbia.

Eight hundred thirty-two pigs housed in a commercial research facility were utilized to evaluate the effects of low phytate corn and phytase enzyme on pig growth and fecal phosphorus excretion. Pigs were randomly allocated by gender to thirty two pens of 26 pigs. One of four corn source/phytase treatments was randomly assigned to each pen: typical corn (TC), typical corn plus 300 FTU phytase (TC+300), low phytate corn (LP) and LP plus 300 FTU phytase (LP+300). From 28 to 127 kg BW pigs were fed fortified corn-soybean diets in a five phase feeding program. Within a phase, diets were formulated to contain equal nutrient and available phosphorus contents by altering the ratios of energy, amino acids and available phosphorus sources. Fecal grab samples were collected from each pen. The right front legs from 5 pigs per pen were collected at slaughter. Initial weight, final weight, ADF, ADG, G:F, HCW, BF, loin depth and calculated lean % did not differ between treatments. Addition of phytase enzyme or substitution of LP for TC reduced fecal phosphorus content 25%, while the combination of LP corn plus phytase reduced fecal phosphorus 54%. Force required to break the MC/MT bones was similar for all treatments. These results indicate that the effects of low phytate corn and phytase enzyme on fecal phosphorus content are similar and additive.

Criteria	TC	TC+300	LP	LP+300	SEM
Initial W, kg	28.3	28.3	28.4	28.4	0.04
Final W, kg	127.1	126.0	126.8	127.5	0.82
ADF, kg	2.23	2.22	2.20	2.23	0.02
ADG, kg	0.85	0.84	0.84	0.85	0.01
G:F	0.378	0.377	0.380	0.377	0.003
Carcass Characteristics					
HCW, kg	95.4	94.5	95.4	95.6	0.68
BF, mm	16.3	16.3	16.5	16.5	0.25
Loin depth, cm	6.88	6.83	6.78	6.78	0.05
Lean, %	55.76	55.61	55.46	55.48	0.15
Fecal Composition					
Moisture, %	71.32	70.71	71.08	70.09	0.94
Phosphorus, % of DM	2.27 <sup>a</sup>	1.69 <sup>b</sup>	1.71 <sup>b</sup>	1.05 <sup>c</sup>	0.05
Bone breaking force, kg	209	202	212	198	5.70

Means in same row with unlike superscripts differ ( $P < .05$ )

**Key Words:** Low Phytate Corn, Phytase Enzyme, Phosphorus Excretion

**175 Efficacy of different phytase products for young chicks and pigs.** N.R. Augspurger<sup>\*1</sup>, D.M. Webel<sup>2</sup>, X.G. Lei<sup>3</sup>, and D.H. Baker<sup>1</sup>, <sup>1</sup>University of Illinois at Urbana-Champaign, <sup>2</sup>United Feeds, Inc. Sheridan, IN, <sup>3</sup>Cornell University, Ithaca, NY.

Two chick trials and one pig trial were done to investigate the phosphorus-releasing efficacy of different phytase products when added to corn-soybean meal diets containing no supplemental inorganic P (Pi). All phytase premixes were assayed (Na-phytate assay) for phytase activity (U/g) prior to use. In the chick trials, five pens of four chicks were fed each diet from 8 to 22-d posthatching. The first chick assay involved feeding five levels of Pi (0, 0.10, 0.20, 0.30, 0.40%) from KH<sub>2</sub>PO<sub>4</sub> with and without 500 U/kg of Natuphos<sup>®</sup> in diets containing 1.0% Ca. Broken-line least-squares regression analysis of tibia ash (mg) vs dietary available P (%) for each series resulted in good fits ( $r^2 = 0.98$ ). Inflection points occurred at 0.347% and 0.314% available P for chicks fed diets without and with Natuphos<sup>®</sup>, respectively. The data also showed constant phytase-induced Pi-release at all levels of available P up to 0.30% of the diet. In the second chick assay, graded levels of Pi (0, 0.05, 0.10, 0.15%) from KH<sub>2</sub>PO<sub>4</sub> were fed and compared to two sources and levels (U/kg) of supplemental phytase in diets containing 0.75% Ca. Linear ( $P < 0.01$ ) responses in tibia ash and weight gain resulted from Pi supplementation. Tibia ash regressed on supplemental Pi intake ( $r^2 = 0.95$ ) provided a standard curve from which bioefficacy (Pi release) could be calculated for each phytase product. At 500 U/kg diet, Natuphos<sup>®</sup> released 0.032% Pi whereas Ronozyme<sup>®</sup> released 0.028% Pi. At 1,000 U/kg, Pi-release values were 0.048% for Natuphos<sup>®</sup> and 0.038% for Ronozyme<sup>®</sup>. The pig trial involved 10 individually-fed pigs (9 kg) per diet, and all phytase products were supplemented to provide 400 U/kg in diets containing 0.60% Ca. Based on the linear regression of fibula ash on supplemental Pi intake ( $r^2 = 0.87$ ), Pi-release values were calculated to be 0.081% for Natuphos<sup>®</sup> and 0.043% for Ronozyme<sup>®</sup>. Three experimental *E. coli* phytase products (expressed in yeast) were also evaluated: ECP1, ECP2, and ECP3 released 0.116%, 0.136%, and 0.108% Pi, respectively. All three of the *E. coli* phytases released more ( $P < 0.05$ ) Pi than either Natuphos<sup>®</sup> or Ronozyme<sup>®</sup>. An in vitro enzymatic Pi-release assay showed promise in predicting phytase efficacy values that were in good agreement with in vivo efficacy values.

**Key Words:** Phytase, Chicks, Pigs

**176 Release of phosphorus from two phytase products.** G. L. Lynch<sup>\*</sup>, W. F. McKnight, and B. W. Cousins, BASF Corporation.

Phytases are a group of enzymes that degrade phytate to yield inorganic phosphorus and various isomers of inositol. Microbial phytase enzymes are known to differ in their ability to react with phytate and to release phosphorus. A series of studies, three consecutive trials identical in design were conducted to determine the relative efficacy of phytase from *Aspergillus niger* (Natuphos) and from *Peniophora lycii* (Ronozyme). For each trial, 400 male broiler chicks were randomly placed in 40 battery cages and assigned to one of ten treatments (4 replications). An industry-typical corn/soy basal diet was formulated to be adequate in all nutrients except phosphorus and calcium, mixed and subdivided into ten aliquots. The basal diet contained 0.20% aP and 0.5% calcium.

Treatments 1-4 were created by adding monocalcium phosphate (MCP) to yield diets containing 0, 0.05%, 0.10% and 0.15% added aP. Limestone was added to maintain Ca at a 2.5:1 ratio with aP. Each enzyme product was analyzed for phytase and added at levels of 150, 300 and 450 FTU/kg diet. (Treatments 5-7 and 8-10 for Natuphos and Ronozyme, respectively). Data from the three trials were combined and treatment responses evaluated using the slope ratio procedure. Significant linear responses for bone ash were found for MCP ( $R^2 = 0.983$ ,  $P = 0.008$ ) and for Natuphos ( $R^2 = 0.986$ ,  $P = 0.007$ ). For Ronozyme the linear response was not significant ( $R^2 = 0.779$ ,  $P = 0.117$ ). A prediction of aP release for Ronozyme was not made based on the non-linearity of the response. Based on these data, the calculated release of available phosphorus relative to MCP for 450 FTU from Natuphos is 0.109%.

**Key Words:** Phytase, Natuphos

**177 Available phosphorus requirement for 33 to 55 kg pigs reared in commercial facilities.** C. W. Hastad<sup>\*</sup>, S. S. Dritz, J. L. Nelssen, M. D. Tokach, and R. D. Goodband, Kansas State University, Manhattan Kansas.

Two experiments were conducted in commercial research barns to determine the appropriate dietary phosphorous level for pigs from 33 to 55 kg. In Exp 1, 600 gilts (initially 43.2 kg) were randomly allotted by weight to one of two dietary treatments (high or low P) for a 98 d trial. Diets were calculated to have low (.30, .28, .27, .27, .24, and .19%) or high (.37, .33, .30, .28, .27, or .26%) available P (aP) in six phases and diets were fed according to a feed budget. There were 25 pigs per pen, and 12 pens per treatment. In Exp 2, 1,260 gilts (initially 33.8 kg) were blocked by weight and randomly allotted to one of five dietary treatments for a 26-d experiment. The corn-soybean meal based diets contained 6% added fat and were formulated to 1.25% total lysine. Available P levels were 0.5, 0.6, 0.7, 0.8, or 0.9 g aP/Mcal ME (.18, .22, .25, .29, or .32% aP). A constant Ca:P ratio (1.1:1) was maintained in all diets. On d 26, one pig from each pen was randomly selected for harvest of the right femur, third and fourth metatarsals (MT3 & MT4), and sixth rib to determine bone properties. In Exp 1, there were no differences ( $P > 0.15$ ) in overall ADG, ADFI or feed efficiency. In Exp 2, from d 0 to 14, ADG increased linearly ( $P < 0.02$ ; 794, 839, 825, 853, and 839 g/d) and gain/feed increased quadratically ( $P < 0.05$ ; .53, .58, .56, .59, and .57) with increasing available P. There were no differences ( $P > 0.69$ ) in ADFI. From d 14 to 26 or overall, there were no differences in growth data between treatments. There were no differences ( $P > 0.66$ ) in bone properties for MT4; however, strain for MT3 was quadratic ( $P < 0.05$ ) with increasing levels of available P (.80, .71, .73, .69, and .79). Bending moment increased ( $P < 0.01$ ) for both the 6th rib (18.7, 25.5, 24.8, 27.7, and 27.6 kg-cm) and femur (289, 338, 319, 339, and 338 kg-cm) with increasing available P. These results indicate that 0.6 aP/Mcal of ME is adequate to promote growth and maintain bone strength for finishing pigs from 33 to 55 kg. This is equivalent to 8 g/d of total P or 3.2 g/d of available P.

**Key Words:** Phosphorus, Bone Strength, Pigs

**178 Effect of zinc oxide and copper sulfate interactions with sodium chloride in nursery pig diets.** T.G. Wiseman<sup>\*</sup> and D.C. Mahan, The Ohio State University.

Previous research suggested that the addition of NaCl to nursery diets improved pig performance, largely due to the Cl ion improving N digestibility. Other research has demonstrated that the addition of dietary zinc oxide or copper sulfate can also enhance pig growth during the postweaning period. Because the Cl ion can alter the pH in the intestinal tract, it could affect the microbial population and mineral status in the intestinal tract. Therefore an experiment was conducted using a 2 X 2 X 2 factorial arrangement in a RCB design conducted in 5 replicates to evaluate if an interaction exists between added dietary levels of NaCl (0 or 0.30%), zinc oxide (0 or 2000 ppm) or copper sulfate (0 or 250 ppm). A total of 176 pigs weaned at  $17 \pm 2$  d of age averaged 6.27 kg BW, and were housed with 4 to 5 pigs per pen in an off-site nursery. Diets for Phase 1 (0-14 d) and Phase 2 (14-28 d) were formulated using feeds typically used for nursery pigs. Dietary treatment levels of NaCl, zinc oxide and copper sulfate were constant during the 28 d trial period. The results showed that the addition of NaCl had no effect (0 vs 0.30%) on daily gain, feed intake or gain: feed ratio. Zinc oxide at 2000 ppm did appear to improve daily gain and daily feed, particularly during the initial 0-14 d period, but responses were not significant ( $P > 0.15$ ), nor

was there a response during the Phase 2 period. There was an interaction ( $P < 0.05$ ) between NaCl and zinc oxide where an improved daily gain occurred when diets were without added NaCl, but when NaCl was added, the response to zinc oxide was not present. Copper sulfate improved daily gains ( $P < 0.01$ ) during both the 0-14 and 14-28 d periods. There was an interaction between NaCl and copper sulfate where daily gains were improved more ( $P < 0.05$ ) during each phase when added NaCl was provided. No interaction occurred between zinc oxide and copper sulfate. These results suggest that the dietary level of NaCl may influence the performance responses to zinc oxide or copper sulfate.

**Key Words:** Salt, Zinc, Copper

**179 Evaluating growth performance, plasma and feces of nursery pigs fed organic zinc polysaccharide complex.** C. A. Boren\*, M. S. Carlson, C. E. Huntington, D. W. Bollinger, and T. L. Veum, *University of Missouri, Columbia, MO*.

This experiment was conducted to evaluate the effects of feeding titrated concentrations of organic zinc in the form of a polysaccharide complex (SQM-Zn: Quali Tech, Inc., Chaska, MN) on growth performance, plasma Zn and Cu concentrations, and fecal Zn and Cu excretion of nursery pigs. One hundred ninety eight crossbred (PIC: C22 X TF4) pigs were weaned (17 d of age; avg. wt. 5.6 .02 kg) and allotted to dietary treatment based on weight and sex. Pigs were housed in an environmentally regulated building with 3 pigs/pen (1.2 x 1.2 m) and 11 pens (replications)/treatment. The experimental Phase 1 nursery diet was fed as crumbled pellets from d 0 to 14. Common diets were fed during Phase 2 (d 15 to 28) and Phase 3 (d 29 to 42). Total lysine concentrations were 1.5 % in Phase 1, 1.25 % in Phase 2, and 1.1 % in Phase 3. All dietary phases contained 135 ppm Zn as  $ZnSO_4$ , 165 ppm Fe as  $FeSO_4$ , and 16.5 ppm Cu as  $CuSO_4$ . Pigs were bled on d 14 to measure plasma Zn and Cu concentrations. The Phase 1 diet utilized 6 dietary Zn treatments: (1) 135 ppm Zn as  $ZnSO_4$ , (2) 125 ppm Zn as SQM-Zn (organic polysaccharide complex), (3) 250 ppm Zn as SQM-Zn, (4) 375 ppm Zn as SQM-Zn, (5) 500 ppm Zn as SQM-Zn, and (6) 2,000 ppm Zn as ZnO. Pigs fed 2,000 ppm Zn as ZnO had higher ( $P < .03$ ) ADG during Phase 2 (d 15 to 28) compared to pigs fed the control or SQM-Zn treatments. During Phase 1, Phase 3 and over the entire 42-d study, pigs had similar ADG ( $P > .05$ ). Dietary treatment had no effect ( $P > .05$ ) on ADFI and feed efficiency in any phase of the experiment. Pigs fed 2,000 ppm Zn as ZnO had the highest plasma Zn concentrations ( $P < .01$ ) compared with all other treatments. Plasma and fecal Cu concentrations were not affected ( $P > .05$ ) by Phase 1 dietary Zn treatments. At the end of Phase 1, pigs fed 2,000 ppm Zn as ZnO had the highest fecal Zn excretion (g/d and %;  $P < .0001$ ) compared to the other dietary treatments. These results indicate that feeding lower concentrations of Zn may not affect nursery pig performance, but will reduce the amount of Zn excreted.

**Key Words:** Zinc, Copper, Pigs

**180 Iron bioavailability of humate in young pigs.** S. W. Kim\*, L. E. Hulbert, H. A. Rachunyo, and J. J. McGlone, *Texas Tech University*.

Humate is derived from mineral humic substances that include several biologically active and inactive compounds which are commonly used for improving soil fertility. Use of humate in swine diets is a relatively new concept. A series of research projects has been conducted to evaluate the efficacy of humate as a feed additive for swine. As a first approach, a study was conducted to test the bioavailability of iron in humate for nursery pigs. Humate contained 8,700 ppm of iron as determined by atomic absorption spectrophotometry. One hundred fifty pigs (Newsham, Colorado Springs, CO) were not given supplemental iron while nursing for 21 d. Pigs were weaned on d 21 and allotted to five treatments (four control treatments with different levels of supplemented iron; 0, 12, 54, and 69 ppm from  $FeSO_4$  and one treatment with 88 ppm iron from humate). Pigs were fed diets for 5 wk ad libitum and water was accessible freely. Body weight and feed intake were measured weekly. Blood samples were taken from pigs on d 28 to determine the number of red blood cells and hemoglobin concentration. Pigs fed a diet with the humate grew faster ( $P < 0.05$ ) during the first week postweaning, but performance was not different during the entire period. Feed intake and gain:feed ratio were the same among treatments. Slope ratio technique was used for the data analysis. The concentration of blood hemoglobin did not respond to dietary iron levels using this

model. However, the number of red blood cells (106/L) was modeled by  $4.438 + 0.017 \times \text{Fe (ppm)}$  from  $FeSO_4$  +  $0.012 \times \text{Fe (ppm)}$  from the humate. Based on the comparison between the slopes (0.012/0.017), iron in humate was 71% as available as the iron in  $FeSO_4$ . However, there was no difference between the slopes for dietary  $FeSO_4$  and humate iron ( $P > 0.05$ ). Humate can replace  $FeSO_4$  as an alternative iron source for pigs at 71% relative bioavailability.

**Key Words:** Nursery Pigs, Iron Bioavailability, Humate

**181 Timing of magnesium supplementation through drinking water to improve fresh pork quality.** B. R. Frederick\*, E. van Heugten, and M. T. See, *North Carolina State University*.

Thirty-two pigs were used to determine the timing effect of Mg supplementation through drinking water on fresh pork quality. Pigs (16 castrated males, 16 females) were individually penned, provided 2.7 kg of feed (0.12% Mg) daily, and allowed free access to water via a nipple waterer for the duration of the study. After 5 d of adjustment, pigs (119  $\pm$  4 kg BW) were randomly allotted by weight and sex to 900 ppm supplemental Mg in drinking water for 0, 2, 4, or 6 d prior to slaughter. Pigs were then transported, approximately 110 km, to the abattoir and slaughtered approximately 45 min after arrival. At 24 h post-mortem, *Longissimus dorsi* and *Semimembranosus* chops were placed on Styrofoam trays with absorbent pads and wrapped in oxygen permeable film for retail fluid loss and color determination at 0, 2, 4, 6, and 8 d of storage at 4°C. Approximately 60 g of each muscle was suspended in a covered plastic container, stored for 48 h at 4°C to determine drip loss. Magnesium did not affect loin pH at 45 min or 24 h post-mortem. However, ham pH tended to be greater in pigs offered Mg supplementation for 2 d than those not supplemented, 5.71 vs. 5.62  $\pm$  0.03, respectively ( $P = 0.08$ ). Drip loss from the loin (3.29, 2.46, 3.16, and 3.55  $\pm$  0.42%) and ham (3.33, 3.26, 3.83, and 3.36  $\pm$  0.30%) were not affected by Mg supplementation for 0, 2, 4, and 6 d, respectively. Furthermore, loin retail fluid loss was not affected by Mg supplementation during retail storage. However, ham retail fluid loss from pigs provided supplemental Mg for 2 d, but not 4 or 6 d, was lower after 4 d (4.15 vs. 6.08  $\pm$  0.52%,  $P < 0.05$ ) and 8 d of storage (6.25 vs. 8.22  $\pm$  0.62%,  $P \leq 0.05$ ) than pigs without Mg supplementation. Minolta L\*, a\*, and b\* color measurements of the loin were not affected by Mg supplementation. Magnesium supplementation for 2 d, but not 4 or 6 d, decreased initial yellowness (b\*) of the ham compared to no added Mg, 6.85 vs. 8.95  $\pm$  0.59 ( $P < 0.04$ ). These data suggest Mg supplementation through drinking water for 2 d can improve color and reduce retail fluid loss of ham.

**Key Words:** Pork Quality, Magnesium Sulfate, Water

**182 Effects of ractopamine dose and feeding duration on pig performance in a commercial finishing facility.** R.G. Main\*, S.S. Dritz, M.D. Tokach, R.D. Goodband, and J.L. Nelsens, *Kansas State University, Manhattan*.

Our objective was to evaluate the impact of ractopamine HCl (Paylean®, Elanco Animal Health) dose and feeding duration on growth performance and carcass composition. Forty-five pens (1,035 gilts; initially 103.2  $\pm$  0.62 kg) were allotted to one of 9 treatments. Treatments included pigs fed 5 or 10 ppm ractopamine for the last 7, 14, 21, or 28 days prior to market and a control treatment without ractopamine. There were 23 pigs per pen and 5 pens per treatment. Diets were corn-soybean meal based, formulated to contain .75 and 1.00 % total dietary lysine for the control and ractopamine supplemented diets, respectively. At slaughter, fat and loin depth were measured to calculate lean percentage. Daily gain (0.66, 0.76, 0.77, 0.77 kg/d for 5 ppm and 0.78, 0.81, 0.78, 0.80 kg/d for 10 ppm for 7, 14, 21, or 28 d) and feed efficiency (G:F; 0.27, 0.31, 0.31, .30 for 5 ppm and .31, .32, .31, .31 for 10 ppm for 7, 14, 21, or 28 d) were increased ( $P \leq .04$ ) for pigs fed 5 ppm ractopamine for 14, 21, or 28 days as well as pigs fed 10 ppm for all durations compared to the control (ADG, 0.60 kg/d; G:F, 0.25). The 5 ppm, 7 day treatment was intermediate in both daily gain and feed efficiency. Ractopamine dose (5 vs. 10 ppm) did not affect ( $P \geq .16$ ) carcass parameters measured. Fat depth decreased (16.3, 15.7, 15.3, 14.8  $\pm$  .36 mm) and lean percentage (56.0, 56.6, 56.8, 57.0  $\pm$  .15%) increased linearly ( $P \leq .01$ ) as ractopamine feeding duration increased from 7 to 28 days. However, the control treatment was intermediate to all other treatments. Ractopamine feeding duration did not affect ( $P \geq .93$ ) yield (76.9, 76.9, 77.0, 76.7  $\pm$  .3 %) or loin depth (67.7, 67.1, 67.4, 67.7  $\pm$  1.5 mm). Feeding



ractopamine supplemented diets at 5 ppm 14 to 28 days and 10 ppm 7 to 28 days prior to slaughter improved growth rate and feed efficiency. Ractopamine feeding duration (in conjunction with increased dietary lysine level) also linearly reduced fat depth and increased lean percentage in this study.

**Key Words:** Ractopamine, Dose, Duration

**183 Effect of ractopamine (Paylean®) feeding program on growth performance and carcass value.** M. T. See\*<sup>1</sup>, T. A. Armstrong<sup>2</sup>, and W. C. Weldon<sup>2</sup>, <sup>1</sup>North Carolina State University, <sup>2</sup>Elanco Animal Health.

To determine if ractopamine (RAC) response can be enhanced by changing the levels in the diet during different phases of feeding, 100 barrows and 100 gilts (initial BW = 71 kg) were randomly allotted to one of four dietary treatments. Treatments were: 1) Control diet containing no RAC wk 0-6; 2) Step-up RAC: 5 ppm wk 1 and 2; 10 ppm wk 3 and 4; and 20 ppm wk 5 and 6; 3) Step-down RAC: 20 ppm wk 1 and 2; 10 ppm wk 3 and 4; and 5 ppm wk 5 and 6; and 4) Average RAC: 11.7 ppm wk 0-6. All diets were formulated to contain 1.2% lysine. Overall, ADG was increased (1.0 vs. .93 kg/d;  $P < .05$ ) and feed/gain decreased (2.77 vs. 3.21;  $P < .01$ ) for pigs fed RAC compared to the control. Feed cost/kg gain did not differ between dietary treatments but total feed cost/pig was greater (\$21.67 vs. \$19.44;  $P < .01$ ) for pigs fed RAC. Loin muscle area, kg of boneless trimmed ham and % fat free lean increased ( $P < .01$ ) in pigs fed RAC. Carcass value was calculated using a common North Carolina pricing system and lean value of the carcass was based on USDA reported prices for boneless pork primal cuts. When value was adjusted to a common final weight, carcass value/pig did not differ ( $P > .10$ ) among treatments but lean value/head was increased by \$4.69 ( $P < .01$ ) for pigs fed RAC. When value was not adjusted for final weight allowing a comparison of equal time on feed, a treatment x sex interaction ( $P < .01$ ) was observed for carcass value with control gilts having the least value (\$114.86) and barrows fed the average RAC treatment having the greatest value (\$132.07) but not significantly different from control barrows (\$130.59). Lean value per head was greater for the Step-up and Average RAC treatments than the Step-down or Control (\$129.27<sup>a</sup>, \$128.11<sup>a</sup>, \$127.35<sup>b</sup>, \$123.49<sup>c</sup>;  $P < .01$ ) treatments. Ractopamine resulted in a favorable response in growth performance and yielded more lean pork at a greater feed cost. Carcass and lean value data indicate that the decision to feed RAC and the feeding program used with it should be made based on marketing plans. Economic benefits from RAC feeding may be achieved if pigs are sold on pounds of lean pork and not on a typical carcass value basis. Economic benefits of RAC feeding may also be achieved for pigs fed to a constant age rather than a constant weight.

**Key Words:** Ractopamine, Growth Performance, Economics

**184 Evaluation of the effects of dietary fat, conjugated linoleic acid, and ractopamine on growth performance and carcass quality in genetically lean gilts.** T. E. Weber\*, B. T. Richert, and A. P. Schinckel, *Purdue University*.

Gilts (n=180; Newsham XL sires x Newsham parent females; initial BW 59 kg) were assigned to a 2 x 2 x 3 factorial arrangement consisting of ractopamine (RAC; 0 or 10 ppm), conjugated linoleic acid (CLA; 1% of a product containing 60% CLA isomers or 1% soybean oil) and dietary fat in an 8 wk feeding trial. Dietary fat treatments consisted of: 1) 0% added fat; 2) 5% choice white grease (CWG); and 3) 5% beef tallow (BT). RAC treatments were imposed when the gilts reached an average BW of 85.5 kg and lasted for the duration of the final 4 wk until carcass data were collected at an average BW of 112 kg. Gilts fed CLA had greater (0.40 vs 0.38;  $P < 0.01$ ) G/F wk 0 to 8 than gilts not fed CLA. Fat provided as CWG or BT tended to increase ADG (0.98 vs 0.95 kg;  $P < 0.10$ ), decreased ADFI (2.45 vs 2.55 kg;  $P < 0.02$ ) and increased G/F ( $P < 0.01$ ) as compared to gilts fed 0% added fat. RAC increased ADG (1.05 vs 0.87;  $P < 0.01$ ) and G/F (0.42 vs 0.35;  $P < 0.01$ ) wk 4 to 8. Gilts fed RAC had greater ( $P < 0.01$ ) dressing percentages than gilts fed no RAC. Added dietary fat tended ( $P < 0.06$ ) to increase dressing percentage. Tenth rib backfat (BF) tended ( $P < 0.06$ ) to be decreased by feeding CLA. Gilts fed RAC tended ( $P < 0.10$ ) to have lower 10th rib BF than gilts fed diets devoid of RAC. Gilts fed CWG had greater ( $P < 0.05$ ) 10th rib BF and last rib BF than gilts fed BT. Feeding RAC increased (57.8 vs 56.2;  $P < 0.01$ ) predicted percent lean. Predicted percent lean was also increased by feeding CLA (57.5 vs 56.5;

$P < 0.03$ ) Gilts fed CLA tended to have greater loin eye areas (LEA;  $P < 0.06$ ) than gilts fed no CLA. Feeding RAC or 5% fat increased ( $P < 0.01$ ) LEA. Gilts fed either CLA or fat tended ( $P < 0.10$ ) to have greater marbling scores than gilts fed diets devoid of CLA or fat. Gilts fed CLA had greater ( $P < 0.01$ ) belly firmness than gilts fed no CLA. These results demonstrate that RAC, CLA, and added fat each enhance certain growth performance and carcass characteristics when used alone or in conjunction with one another.

**Key Words:** CLA, Ractopamine, Dietary Fat

**185 Effects of ractopamine and carnitine in diets containing 5% fat for finishing pigs.** S. A. Trapp\*<sup>1</sup>, B. T. Richert<sup>1</sup>, A. P. Schinckel<sup>1</sup>, and K. Q. Owen<sup>2</sup>, <sup>1</sup>Purdue University, West Lafayette, IN, <sup>2</sup>Lonza, Inc., Fair Lawn, NJ.

To study the effect of ractopamine (RAC) in conjunction with carnitine in elevated fat diets, three hundred gilts (avg. initial BW = 85.4 kg) of two terminal crosses (European, ET; and US, UST) were assigned diets fed for the last four weeks before slaughter. Five dietary treatments (TRT) were used: 1) control; 2) 50 ppm carnitine; 3) 5 ppm RAC; 4) 50 ppm carnitine and 5 ppm RAC; and 5) 10 ppm RAC. All diets were formulated to 1.15% lysine and contained 5% added choice white grease. The gilts were weighed and feed intake was recorded on d 0, 14, and 28. In addition, 3 gilts/pen (36/TRT) were ultrasonically scanned on d 0, 14, and 28 for backfat and loin eye area to estimate composition and tissue accretion curves. Individual hot carcass weight and carcass ultrasound of loin and backfat depth measurements were taken at a commercial pork processor. Pigs fed TRTs 4 and 5 had greater ADG during d 0-14 (834, 866, 952, 1052, 1073 g/d,  $P < .001$ , TRTs 1-5, respectively) and d 0-28 (854, 845, 907, 960, 943 g/d,  $P < .01$ , TRTs 1-5, respectively) compared to pigs fed treatments 1 and 2. No difference was found in ADFI between diets. Gilts fed TRTs 3, 4, and 5 had greater gain:feed ( $P < .01$ ) from d 0-14 (375, 379, 430, 451, 466 g/kg, TRTs 1-5, respectively) and d 0-28 (357, 348, 391, 399, 398 g/kg, treatments 1-5, respectively) compared to pigs fed TRTs 1 and 2. Pigs fed diets with RAC had increased carcass loin depths (67.8, 66.4, 70.6, 70.5, 71.7 mm;  $P < .05$ , TRTs 1-5 respectively). However, only TRTs 3 and 5 had increases in plant measured percent lean ( $P < .01$ ) compared to the other TRTs. The UST gilts tended to have greater ADG d 0-28 (922 vs 885 g/d;  $P < .07$ ), but had increased plant fat depth (15.5 vs 13.4 mm;  $P < .001$ ) with reduced plant percent lean (56.0 vs 56.6%;  $P < .01$ ) and reduced carcass yield (75.2 vs 76.1%;  $P < .01$ ) compared to the ET gilts. This data indicates that during the first 14 days while feeding ractopamine, carnitine may enhance the ractopamine response with increased body weight gain and improved feed efficiency.

**Key Words:** Carnitine, Ractopamine, Pigs

**186 Interactive effects between Paylean® (Ractopamine HCl) and dietary lysine on pork quality and loin, belly, and ham composition.** M. J. Webster\*, R. D. Goodband, M. D. Tokach, J. A. Unruh, J. L. Nelssen, S. S. Dritz, D. E. Real, J. M. DeRouchey, J. C. Woodworth, and T. A. Marsteller<sup>1</sup>, *Kansas State University, Manhattan, KS*, <sup>1</sup>Elanco Animal Health, Indianapolis, IN.

A total of 432 pigs was used to evaluate the effects of Paylean and dietary lysine on pork quality and loin, belly, and ham composition. The 12 dietary treatments included Paylean (0, 5, and 10 ppm) and 4 levels of lysine. For pigs fed no Paylean, lysine levels were 0.6, 0.8, 1.0, and 1.2%. For pigs fed Paylean, lysine levels were 0.8, 1.0, 1.2, and 1.4%. The dietary treatments were fed to pigs from 79 to 109 kg. There were three pigs per pen and 12 pens per treatment (six pens of each sex). One pig per pen was harvested on d 14 and d 28 of the experiment. At 24 h postmortem, carcasses were fabricated into the primal cuts. After a 30 min bloom, the loin surface at the 10<sup>th</sup> rib was analyzed for color (Hunter L\*a\*b\* values), drip loss, ultimate pH, visual color, firmness, and marbling. After spareribs were removed and the belly trimmed, belly firmness was evaluated by suspending the belly perpendicularly over a bar (skin side up) and the distance was recorded between the belly ends initially and after a five-minute period. A sample from each loin (9<sup>th</sup> rib), ham (biceps femoris), and belly, from the same anatomical region, was collected, frozen, and analyzed for protein, lipid, ash, and moisture content. For the endpoint data, increasing Paylean decreased (linear,  $P < .0001$ ) initial and 5-minute belly firmness. Visual marbling score decreased (linear  $P < .05$ ) as lysine increased for pigs

fed Paylean. As Paylean dosage increased, loin fat percentage decreased (linear,  $P < .04$ ) and loin crude protein percentage increased (linear,  $P < .01$ ). In addition, as Paylean dosage increased, belly moisture and crude protein percentage increased (linear,  $P < .05$ ) while belly fat percentage decreased (linear,  $P < .001$ ). The results indicate that pigs fed Paylean and increasing levels of lysine will have less loin marbling and belly firmness compared to control pigs.

**Key Words:** Paylean®, Lysine, Finishing Pigs

**187 Interactive effects between Paylean® (Ractopamine HCl) and dietary lysine on finishing pig growth performance, carcass characteristics and tissue accretion.** M. J. Webster\*, R. D. Goodband, M. D. Tokach, J. A. Unruh, J. L. Nelssen, S. S. Dritz, D. E. Real, J. M. DeRouchey, J. C. Woodworth, and T. A. Marsteller<sup>1</sup>, *Kansas State University, Manhattan, KS*, <sup>1</sup>*Elanco Animal Health, Indianapolis, IN*.

A total of 432 pigs was used to evaluate the effects of Paylean and dietary lysine on finishing pig growth performance, carcass characteristics and tissue accretion. The 12 dietary treatments included Paylean (0, 5, and 10 ppm) and 4 levels of lysine. For pigs fed no Paylean, lysine levels were 0.6, 0.8, 1.0, and 1.2%. For pigs fed Paylean, lysine levels were 0.8, 1.0, 1.2, and 1.4%. Dietary treatments were fed from 79 to 109 kg. There were three pigs per pen and 12 pens per treatment (six pens of each sex). Pigs were weighed and feed disappearance was recorded every 7 d for the 28 d period. One pig per pen was harvested on d 14 (midpoint) and d 28 (endpoint) of the experiment. Carcass parameters were taken at 24 h postmortem and one side of each carcass was ground and sampled for proximate analysis. At the beginning of the experiment, twelve pigs (6 of each sex) were harvested, ground, and sampled for proximate analysis. In the 28 d period, there was an increase (linear,  $P < .001$ ) in ADG and G/F as Paylean increased. For pigs fed Paylean, increasing dietary lysine increased and improved (quadratic,  $P < .07$  and  $P < .04$ ) overall ADG and G/F, respectively. Pigs fed increasing Paylean had increased (linear,  $P < .01$ ) live weight, yield, hot, and cold carcass weights, lean percentage, and loin eye area. Furthermore, as Paylean levels increased, leaf fat, tenth rib backfat, and average backfat thickness decreased (linear,  $P < .01$ ). Additionally, by adding Paylean or lysine to the diet, there was an increase (linear,  $P < .0001$  and quadratic,  $P < .02$ , respectively) in moisture and protein accretion and a decrease (linear,  $P < .01$ ) in fat accretion. The results indicate that pigs fed Paylean need at least 1.0% dietary lysine to optimize growth, carcass parameters, and tissue accretion.

**Key Words:** Paylean®, Lysine, Finishing Pigs

**188 Effects of lysine and energy density of performance and carcass traits of finishing pigs fed ractopamine.** D.C. Brown\*, J.K. Apple<sup>1</sup>, C.V. Maxwell<sup>1</sup>, K.G. Friesen<sup>1</sup>, M.E. Davis<sup>1</sup>, R.E. Musser<sup>2</sup>, Z.B. Johnson<sup>1</sup>, and T.A. Armstrong<sup>3</sup>, <sup>1</sup>*University of Arkansas*, <sup>2</sup>*The Pork Group, Rogers, AR*, <sup>3</sup>*Elanco Animal Health, Greenfield, IN*.

A total of 216 crossbred barrows and gilts (Yorkshire x Landrace females mated to Dekalb EB sires) were used to test the effects of energy density (E) and lysine-to-energy ratio (Lys) on performance and carcass characteristics of finishing pigs fed ractopamine. Pigs, with an average initial BW of 84 kg, were blocked by weight and sex and assigned to one of 36 pens. Pens were randomly assigned to 1 of 6 dietary treatments arranged in a 2 x 3 factorial design, with two levels of E (3.30 or 3.48 Mcal/kg of ME) and three lysine-to-energy ratios (1.7, 2.4, or 3.1 g lysine/Mcal). Ractopamine was included in all diets at a level of 10 mg/kg, and pigs were fed the experimental diets for 28 d prior to harvest. Individual pig weights and feed disappearance were recorded weekly to calculate ADG, ADFI, and G:F. Upon completion of the feeding trial, pigs were transported to a commercial pork harvest/processing plant, and hot carcass weight (HCW) was recorded. After the 24 h chilling period, fat and LM depths at the 10<sup>th</sup> rib were measured with a Fat-O-Meater, and used to calculate standardized lean yield (SLY). Overall main effects means are reported where no E x Lys interaction ( $P > 0.05$ ) was observed. Results indicate that to optimize lean tissue deposition in pigs fed ractopamine, 3.3 Mcal/kg is sufficient energy, and the Lys to energy ratio may be higher than reported in the literature and higher than levels currently utilized in the industry.

Item	Energy (Mcal/kg)			Lysine (g/Mcal)			
	3.30	3.48	SE	1.7	2.4	3.1	SE
ADG, kg	0.640	0.679	0.02	0.579	0.660	0.741 <sup>c</sup>	0.03
ADFI, kg	2.15	2.08	0.04	2.12	2.13	2.09	0.05
G:F	0.298 <sup>a</sup>	0.326 <sup>b</sup>	0.01	0.272	0.310	0.355 <sup>c</sup>	0.01
HCW, kg	78.3	78.5	0.50	76.3	79.5	79.2 <sup>c</sup>	0.63
Fat depth, mm	19.1 <sup>a</sup>	20.2 <sup>b</sup>	0.39	20.7	19.3	19.0 <sup>d</sup>	0.49
LM depth, mm	59.1	58.7	0.69	56.7	59.3	60.7 <sup>c</sup>	0.85
SLY, %	51.4 <sup>a</sup>	50.6 <sup>b</sup>	0.30	50.1	51.2	51.7 <sup>c</sup>	0.37

<sup>a,b</sup>E effects ( $P < 0.05$ ). <sup>c</sup>Linear Lys effect ( $P < 0.01$ ).

<sup>d</sup>Linear Lys effects ( $P < 0.02$ ).

**Key Words:** Swine, Ractopamine, Energy x Lysine Level

**189 The efficacy of Paylean® (ractopamine hydrochloride) addition to late-finishing swine diets in a controlled cycling hot environment.** J.D. Spencer\*, C.A. Stahl<sup>1</sup>, A.M. Gaines<sup>1</sup>, D.C. Kendall<sup>1</sup>, G.F. Yi<sup>1</sup>, J.W. Frank<sup>1</sup>, E.P. Berg<sup>1</sup>, D.J. Jones<sup>2</sup>, and G.L. Allee<sup>1</sup>, <sup>1</sup>*University of Missouri, Columbia, MO*, <sup>2</sup>*Elanco Animal Health, Greenfield, IN*.

To determine the efficacy of Paylean addition to late-finishing swine diets during high ambient temperatures, seventy-two barrows (Newsham x PIC 327) (81 kg) were utilized in a growth study with a 2 x 2 factorial arrangement of treatments with two controlled environments (constant 21°C, 50% relative humidity (TN), or a cycling temperature 27 to 35°C (HS)) and two levels of Paylean addition (0 or 10 ppm). Nutrient content was the same in both diets (1.15% lysine, 3513 kcal ME/kg). There were six replicate pens/treatment with three pigs/pen. Pigs were weighed and scanned via real-time ultrasound for measurement of 10<sup>th</sup> rib backfat (BF) and loin eye area (LEA) weekly. Pigs were harvested at approximately 105 kg for pH and color measurement of the ham and loin. During the growth trial (d 0-26), there was no interaction between temperature and Paylean level ( $P > .15$ ). HS reduced ADFI (HS vs. TN) (1.78 vs. 2.58 kg/d;  $P < .01$ ), ADG (.54 vs. .88 kg/d;  $P < .01$ ) and G:F (.30 vs. .34;  $P < .01$ ). Paylean addition, independent of environmental temperature, improved ADG (0 vs. 10 ppm) (.67 vs. .75 kg/d;  $P < .09$ ) and G:F (.30 vs. .34;  $P < .01$ ). Paylean addition did not significantly affect feed intake ( $P > .10$ ). Additionally, HS reduced BF accretion (+.05 vs. +.25 cm;  $P < .01$ ) and LEA gain (+3.56 vs. +7.50 cm<sup>2</sup>;  $P < .01$ ). Paylean addition also reduced BF accretion (+.20 vs. +.10 cm;  $P < .08$ ) but increased LEA gain (4.64 vs. 6.43 cm<sup>2</sup>;  $P < .08$ ), regardless of temperature. Paylean had no effect on meat quality. Hams and loins from pigs reared in the hot environment had a significantly higher ultimate pH ( $P < .05$ ). Supplementing late-finishing swine diets with 10 ppm Paylean resulted in similar improvements in ADG (10 and 14%) and GF (14 and 18%) (TN, HS, respectively) in both environments. Paylean addition also reduced BF and increased LEA accretion in both environments with no effect on meat quality attributes.

**Key Words:** Swine, Ractopamine, Temperature

**190 Effect of ractopamine on optimum dietary phosphorus regimen for pigs.** T.R. Lutz\* and T.S. Stahly, *Iowa State University, Ames, IA*.

Ten replications of individually-penned gilts from a high-lean strain were utilized to determine the effect of ractopamine (RAC) on the optimum dietary available phosphorus (AP) regimen. At 70 kg BW, pigs were randomly allotted to a corn-soybean meal basal diet (.08% AP) adequate in all nutrients except AP. The basal diet was supplemented with mono-dicalcium phosphate to create six AP concentrations (.08, .13, .18, .23, .28, .33%) and ractopamine HCL to create two RAC concentrations (0 vs. 20 ppm). A constant Ca/AP ratio of 2.5:1 was maintained in each diet. BW gain and feed intake were recorded weekly for 5 weeks and total urine output was collected via urinary catheter the last two days of each 7-day period. Over the five periods, RAC improved ( $P < .01$ ) BW gain (1075 vs. 934 g/d) and gain/feed ratio (431 vs. 371 g/kg), but lowered ( $P < .01$ ) P content of BW gain (4.66 vs. 4.05 g/kg) and urinary P excretion (219 vs. 67 mg/d) independent of dietary AP. The magnitude of change in BW gain and P content of BW gain was reduced in later periods of growth. Dietary AP additions also improved ( $P < .01$ ) daily BW gains and P accretion, P content of BW gain, and efficiency of feed utilization ( $P < .07$ ). To achieve maximum BW gain, the amount of AP needed was not altered by RAC. However, when defining P needs as

the inflection point at which urinary P excretion increases (as indicator of when absorbed P exceeds metabolic needs), an additional .05% to .15% AP was needed in RAC pigs depending on the stage of growth. To achieve the same P content of BW gain, an indicator of the adequacy of the bone mineral content of gain, an additional .05% AP was needed in the RAC pigs. Based on these data, RAC does not alter the amount of AP needed to optimize rate and efficiency of BW gain but does increase the AP needed to maintain P content of body growth equivalent to non-RAC pigs.

**Key Words:** Ractopamine, Phosphorus, Pig

**191 Effect of nutritional levels while feeding ractopamine on carcass composition and growth.** A. P. Schinckel\*, C. T. Herr, D. C. Kendall, J. C. Forrest, and B. T. Richert, *Purdue University, West Lafayette, IN.*

Barrows (BW = 69.6 kg) were allotted by weight to evaluate the effects of dietary lysine levels while feeding ractopamine (RAC) on carcass composition and growth. Treatments (TRT) 1 and 2 were fed throughout the six-week trial, while TRT 3 changed weekly. Treatments were as follows: 1) 16% CP, .82% lys control diet; 2) 16% CP diet, .82% lys; 3) a phase fed diet sequence, 18% CP, 1.08% lys during wk 1 and 4, 20% CP, 1.22% lys during wk 2 and 3, 16% CP, .94% lys during wk 5, and a 16% CP diet .82% lys during wk 6. Diets for TRT 2 and 3 contained 20 ppm RAC. Diets for TRT 3 were designed to meet the predicted lys requirements. Pigs were marketed when the mean block weight reached 108.8 kg. Initial carcass composition was predicted from live weight and live ultrasonic tenth rib backfat, last rib backfat, and loin eye measurements. The four lean cuts from the right side of the carcasses (N = 15 per TRT) were dissected into lean and fat tissue. The other cut soft tissue was from the jowl, ribs, and belly. Proximate analyses were completed on the three tissue pools and a sample of fat tissue from the other cut soft tissue. Percent lipid was lower in the dissected lean (5.25, 5.39, and 4.44; TRT 1, 2, and 3 respectively) and other cut soft tissue (29.4, 27.9, 23.5) for TRT 3 pigs ( $P < .05$ ). Pigs fed RAC had greater fat-free lean (39.4, 42.4, 46.5 kg;  $P < .01$ ) and lipid free soft tissue mass (46.6, 49.5, 53.5 kg;  $P < .01$ ). Pigs on TRT 3 had lower fat tissue (21.5, 21.3, 19.0 kg;  $P < .05$ ) and soft tissue lipid mass (14.2, 14.2, 12.0 kg;  $P < .05$ ) than TRT 1 pigs. Ractopamine and phase fed lysine increased fat-free lean gain (374, 448, 563 g/d;  $P < .01$ ) and lipid-free soft tissue gain (431, 501, 613 g/d;  $P < .01$ ). Pigs from TRT 3 had decreased fat tissue gain (242, 221, 177 g/d;  $P < .05$ ) and soft tissue lipid gain (155, 142, 97 g/d;  $P < .05$ ) than TRT 1 pigs. This trial indicates that carcass tissue and compositional growth are affected by both the dietary lysine and RAC levels.

**Key Words:** Pigs, Ractopamine, Carcass Tissue Growth

**192 Development of a swine growth model to describe the compositional growth of pigs fed ractopamine.** A. P. Schinckel\*, N. Li, P. V. Preckel, B. T. Richert, and M. E. Einstein, *Purdue University; West Lafayette, IN.*

The objective of this research was to utilize recent ractopamine (RAC) research data and develop an updated growth model to describe the daily growth of pigs fed RAC. Six parameters were taken into account. Increases of 19.4, 22.6, and 26.2% for daily protein accretion (PA) were assumed for 5, 10, and 20 ppm RAC level (RL, ppm) for an overall 40 kg feeding period. The relative ractopamine response (RR) described the rapid increase and subsequent decline in the RAC response as a function of weight gain on test (BWG). The reduction in feed intake was modeled as  $.04 (RL/20)^{-7}$  for the first 20 kg of BWG and then increasing to  $.08 (RL/20)^{-7}$  at 40 kg BWG on RAC. The ratio of fat-free lean gain to PA was modeled to increase an average of 14.1% over the 40 kg feeding period; and to increase slightly when lysine and essential amino-acid requirements were met. The ratio of carcass fat gain to empty body lipid gain was modeled to increase when lysine and essential amino-acid levels were met. The model predicted the PA and fat free lean given the dietary lysine intakes. The percent lysine in PA was model to increase with the feeding of RAC from 6.8 to about 7.2% depending on RAC level and BWG. Equations predicting carcass measurements such as fat depth and loin muscle depths were modified to incorporate prediction biases produced by RAC. The model was compared to recent research results. The model predicted changes for a 28 d feeding period starting at 78 kg in the growth rate (1.01, 1.13, 1.14, and 1.15 kg/d), feed efficiency (0.37, 0.41, 0.42, and 0.43), dressing percentage (74.9, 76.1, 76.3, and

76.6), and percent fat-free lean (49.4, 51.1, 51.6 and 52.2), loin muscle area (38.3, 42.3, 43.1, 44.1  $\text{cm}^2$ ), 10th rib fat depth (20.8, 19.8, 19.5, and 19.0 mm), fat free lean gain (325, 443, 465, 492 g/day) comparable to recent research data for 0, 5, 10, and 20 ppm. The model allows the RAC response to be added to farm specific pig growth curves.

**Key Words:** Pigs, Ractopamine, Compositional Growth

**193 Managing the gilt for maximum lifetime production.** G. R. Foxcroft\*, J. Patterson, H. Willis, and F. Aherne, *Swine Research and Technology Centre, Edmonton, Alberta, Canada.*

Two key issues need to be considered in the selection and conditioning of gilts for entry to the breeding herd. Firstly, their inherent genetic merit for reproductive traits. Secondly, environmental influences that might affect gilt development and subsequent reproductive performance. Development of specific dam-line females has addressed the first issue, but this has occurred against ongoing selection pressure for growth and carcass traits that may have indirect and negative outcomes for breeding performance. Nevertheless, the performance of contemporary dam-line females is impressive, given the increases in lean growth performance of their offspring. Litter of origin has a major impact on subsequent reproductive performance and the physiological basis for these differences seem to be as diverse as those reported for genotypes with differences in embryonic survival. However, the uterine environment in which the gilt develops, as much as inherent genetic merit of littermate females, may influence sexual maturation and subsequent fertility. Postnatal nutrition, and interactions between growth, puberty onset, and lifetime reproductive performance have been extensively studied. A minimum growth threshold exists, below which growth and metabolic state will delay the onset of boar-induced puberty. More limited data suggest an upper threshold, above which very high growth rates may also delay the onset of puberty. Within these growth thresholds, there is no consistent evidence that any particular age or weight at breeding confers a production advantage in terms of lifetime reproductive performance; however, potential economic and welfare disadvantages of breeding at heavier weights need to be considered. The well documented benefits of identifying, and capitalizing on, early sexual maturation to enhance lifetime performance, provide a convincing case for important refinements in gilt management.

**Key Words:** Gilt, Management, Reproduction

**194 Relationship of protein and amino acid nutrition to reproduction in sows.** R.D. Boyd\*, M.E. Johnston, and R.A. Cabrera, *PIC USA, Inc. Franklin KY.*

Prolific females require better nutrition and feeding practice because of larger litter size. Life-time pig output will be compromised if body protein and fat are not properly managed. First litter females are especially vulnerable because they can lose  $\geq 15\%$  of whole body protein. Conservation of body protein mass during first lactation minimizes wean to estrus interval and increases second litter size by up to 1.2 pigs per litter. The ability to influence litter-size by amino acid nutrition is a new dimension in our understanding. Nutritional strategy during first pregnancy may impact reproductive ability for first litter females since there appears to be a minimum body size needed to support a rapid return to estrus. Nutrient needs increase exponentially in late pregnancy. An increase in feed level will prevent loss of maternal body protein that would otherwise be mobilized to support fetal and mammary growth. Nitrogen retention is estimated to increase from 9-10 g/d at mid-pregnancy to 17-18 g/d in late pregnancy. In a recent study, first litter females averaged 9.82 kg milk/d for a 21 day lactation. Second and third litter sows averaged 10.35 kg/d. Milk production was 95% of peak by day 10 of lactation and sows were in greatest negative lysine balance during the first 6 days. Nearly 45% of the total loss in body protein occurred within the first 6 days. This could be reduced to 30-35% by using a more aggressive feeding strategy after parturition. There appear to be 2 phases in lactation for lysine need (day 2-12 vs 12-21). The lysine requirement for lactation can be predicted with accuracy, but we are not able to predict the second limiting amino acid. Threonine and valine could be co-limiting for corn-soy diets for prolific sows nursing 10-11 pigs. Empirical studies are needed to refine the ideal pattern so that synthetic lysine can be used with more confidence. A phase feeding strategy during pregnancy and lactation is advised.

**Key Words:** Sow, Nutrition, Amino Acids

**195 Relationship of carbohydrate and lipid nutrition to reproduction in sows.** Bas Kemp\* and Henry Van den Brand, *Wageningen University, Wageningen, The Netherlands.*

Due to the high demands for milk production and a low feed intake capacity, sows lose considerable amounts of body reserves during lactation. Especially in the first litter sow this results in an impaired reproductive functioning after lactation. One approach that has been followed to reduce mobilisation of body stores is increasing the dietary fat content. Several reviews state that ME intake can be increased by about 3-32% when using high fat diets. However, fat as an energy source also seems to increase milk fat content. To study the effects of high fat diets on partitioning of energy over sows and piglets our laboratory has conducted several experiments in which fat and carbohydrate rich diets were compared. Generally, it was found that high fat diets increase fat content of the milk, result in fatter piglets at the end of lactation and result in an increased body fat loss in the sows when diets are fed on an isocaloric basis. Fat rich diets may be beneficial in a hot climate since heat production of sows is lower when fat is used for milk production instead of carbohydrates. However the milk fat driving effect of the fat rich diet makes it unlikely that fat rich diets will help the sow to prevent loss of body condition even when the energy intake is higher. It may be that carbohydrate rich diets would positively influence reproductive characteristics of sows during lactation. Carbohydrate rich diets stimulate insulin and IGF-1 production and these hormones are believed to stimulate LH release from the pituitary gland and to stimulate growth of follicles. In the catabolic first litter sow, however, insulin stimulating diets fed during lactation only resulted in small effects on reproductive characteristics like LH release during and after lactation, peri-ovulatory reproductive hormone profiles, ovulation rate and embryonic survival. However, after weaning, feeding of carbohydrate rich diets instead of a fat-rich diet can result in a shorter weaning to estrus interval.

**Key Words:** Nutrition, Reproduction, Sows

**196 Feeding and managing the boar for optimal reproductive capacity.** M. E. Wilson\*, *Minitube of America, Inc.*

Breeding boars and AI boars are a relatively small part of the pig population. Because of this fact, little attention and testing has been done to determine the specific dietary needs of working boars. This paper will review the limited published nutritional data with boars and try to correlate this with field studies on nutrition and management that have been conducted by industry to impact optimal production of the boar. One key to profitability in a boar stud is feeding a diet that allows boars to produce large quantities of high quality semen and maintain respectable body condition and soundness. Restricted feeding programs are used to maintain boars for semen collection over a longer period of time. Since boar turnover in most studs is relatively rapid due to

replacement with higher indexing boars, the restricted feeding program may not provide the best economic return for the boar stud. Increasing feed intake has a positive effect on sperm production while severe restriction adversely affects sperm output and libido of the boar. Boars that gain weight will have higher sperm production than boars maintaining or losing weight. A body condition score of 3 on a scale from 1-5 is desirable. Factors of production such as age, collection frequency, ambient temperature, genetics, and health status all have an important impact on making nutritional decisions regarding the boar diet. It is still important to take care of the basics when evaluating boar nutrition. Further investigation is required regarding the influence of nutrition on sperm production under different environmental conditions. More concerted effort is needed to research techniques to track fertility of semen in relationship to dietary ingredients. The role of fatty acids, such as DHA, appears to have an effect on fecundity in sows when they are inseminated with semen from boars fed specific fatty acid supplements. It is important to find these correlations to fertility to justify costs of specialty ingredients going into boar diets.

**Key Words:** Boar, Nutrition, Sperm Output

**197 Feeding management of the breeding herd: A systems approach.** D. S. Pollmann\*, *Murphy Farms, LLC, Ames, IA.*

Although nutritional concepts that affect sow productivity are commonly researched, the implementation of science-based feeding programs for the breeding herd is a major challenge, especially in large-scale pork production systems. Numerous factors (facility design, feed delivery systems, genetic differences, varying seasonal challenges, program variances and interpretation of the prescribed standard operating procedures) add to the complexity of implementation of well-managed feeding programs. Key performance indicators will be discussed as monitoring tools to ensure that the desired feeding program is effectively implemented. Commonly observed symptoms due to marginal gestation and lactation feeding program implementation will be discussed. Nutritional recommendations will be provided on feeding programs for gilt development, pre-breeding strategies, and ways to enhance feeding during gestation, lactation, and post-weaning. Methods will be reviewed of effective ways to have production personnel understand the science of the nutritional programs and the importance of monitoring and adhering to the prescribed feeding programs. The blending of known nutritional concepts in a labor efficient and easily understood feeding program is of critical nature for successful pork production. The true value of well-conducted research is the ability to enhance productivity and profitability.

**Key Words:** Breeding Herd Nutrition, Sow Productivity, Feeding Program Implementation

## Odor And Nutrient Management

**198 Intrinsic phytase reduces excretion of volatile organic compounds in pigs.** A. Woldeghebriel\*<sup>1</sup>, A. Koenigsfeld<sup>1</sup>, and A. Mathew<sup>2</sup>, <sup>1</sup>*Lincoln University, Jefferson City MO*, <sup>2</sup>*University of Tennessee, Knoxville TN.*

A study involving three wk-old pigs (n=84) was conducted to evaluate the efficacy of intrinsic phytase (IP) from wheat middlings (WM) on BW gain of pigs, and ammonia and VFA excretion in feces. IP was provided by substituting 25% of WM for an equal part of corn in the corn-soybean meal based diets. The pigs were housed in pens (7/pen), with diets randomly assigned to pens (3 pens/diet). Diets used were: corn soybean meal-based control diet (D-1), D-1 plus microbial phytase (MP; Natuphos, 1,200 PU/g; D-2), D-1 plus IP (D-3), and D-3 plus MP (D-4). The diets were also designated as either low (D-1 and D-2), or high (D-3 and D-4) fiber diets. Feed was offered once/d on a regular (D-1, D-3) or, phase-fed (D-2, D-4) basis with free access to water 24 h/d. Fresh fecal samples collected from pens were used to determine VFA, and ammonia concentrations. Results from the study indicated that pigs fed diets containing MP consumed more feed ( $P < .05$ ), gained faster ( $P < .05$ ), and were 14.5% more efficient than D-1 fed pigs. Pigs fed high-fiber diets with/without MP consumed more, and gained faster ( $P < .05$ ) than D-1 fed pigs. VFA concentration in feces from pigs fed D-1 or D-2 was greater ( $P < .01$ ) than in pigs fed D-3 or D-4. Also, VFA in feces from pigs fed D-4 was greater ( $P < .01$ ) than in D-3 fed pigs. The

level of ammonia in feces within each fiber category was not affected by treatment. However, ammonia in feces from pigs fed D-3 or D-4 was greater ( $P < .05$ ) than from pigs fed D-1 or D-2. In conclusion, addition of MP, or IP to the corn soybean meal-based diet improved feed intake, feed efficiency, and weight gain of pigs, and reduced ammonia and VFA excretion in feces. IP can not substitute MP in a 1:1 ratio however, it is a cheaper but less effective alternative to MP.

**Key Words:** Phytase, VFA, Ammonia

**199 Effects of phytase on nutrient digestibility and amount of odorous compounds in slurries of weaned pigs.** Q.M. Yang\* and S.K. Baidoo, *Southern Research and Outreach Center, University of Minnesota.*

Crossbred weaned pigs (n=216, BW of 5.8kg and 20 d of age) were randomly allotted to 3 dietary treatments with 9 pen replicates per treatment. The dietary treatments were (1) Control: Corn-SBM with 100% dicalcium phosphate; (2) Treatment 1: with 50% dicalcium phosphate + 500 phytase ((Natuphos<sup>®</sup>, BASF) units (PU/kg diet); (3) Treatment 2: without dicalcium phosphate + 500 phytase units/kg diet. The pH, ammonia emission and volatile fatty acids (VFAs) in slurries, and the digestibility of nutrients in the diets were determined. The results indicated that phytase supplementation in diets improved the digestibility

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of organic phosphorus (P). Total P and organic P in feces from control diet were higher ( $P < 0.05$ ) than the feces from diets with supplemented phytase, but nitrogen content of feces was not ( $P > 0.05$ ) influenced by dietary treatments. Phytase supplementation had no effect on pH,  $\text{NH}_3$  and VFAs of slurry. The pH of fresh pig feces diluted with water (1:2.5) and urine (1:2.5) were, respectively,  $5.56 \pm 0.28$  and  $7.08 \pm 0.18$ . The pH of feces diluted with urine decreased by 2.8% within 2 days and then increased by 17.1%, the pH of feces diluted with water decreased by 3.7% within 2 days and then increased by 21.2% during 14-d storage. The  $\text{NH}_3$  emission from feces diluted with water was lower ( $P < 0.01$ ) than feces diluted with urine within 14-d storage period. The emission of  $\text{NH}_3$  was correlated ( $r = 0.81$ ) with pH in slurry within a pH range from 5.5 to 8.2.  $\text{NH}_3$  emission and the content of VFAs in slurry increased during the 14-d storage and these increases were dependent on the amount of ammonium in slurry. In summary, phytase supplementation improved the digestibility of organic P and reduced the P content in the feces, but did not decrease the production of ammonia and VFAs of slurry. Urine or ammonium amount in slurry increased its pH and produced more  $\text{NH}_3$ .  $\text{NH}_3$  emission and the content of VFAs in slurry increased during the 14-d storage periods.

**Key Words:** Swine manure, Phytase, Ammonia

**200 Effect of high available phosphorus (HAP) corn and phytase on phosphorus (P) excretion in finishing beef cattle.** S. L. Hankins\*, J. D. Arseneau, S. A. DeCamp, R. P. Lemenager, and A. L. Sutton, *Purdue University, West Lafayette, IN.*

Two trials were conducted to determine the effect of microbial phytase (PHY) and HAP corn substitution for normal corn (NC), on the nutrient digestibility and performance of finishing beef steers. In Exp. 1, four crossbred steers (Initial BW=345 kg) were used in a 4X4 Latin square design and fed four high concentrate diets ad libitum. The diets were: 1) NC/15% corn silage (CS) balanced to NRC (1996) specifications for protein, vitamins and minerals (STD), 2) diet 1 plus 0.10% PHY (STD+PHY), 3) diet 1 with HAP corn replacing NC and 15% CS (HAP), and 4) diet 3 with 0.10% PHY (HAP+PHY). No supplemental P was added to the diets. Steers were adapted to metabolism stalls for five days prior to trial initiation. Total feces and urine were collected following a 9 d diet adaptation and 5 d collection. Exp. 2 utilized 48 crossbred steers (Initial BW=273 kg) individually fed a high concentrate diet with no supplemental P for a 168 d feeding period. Steers were allotted to four TRT including: 1) STD; 2) STD+PHY; 3) STD, limit fed to 85% of ad lib intake (LIM); and 4) STD+PHY, limit fed to 85% of ad lib intake (LIM+PHY). Limit fed steers were increased to ad lib intake starting on d 75. Steer weights were taken at the initiation, every 28 d and at the completion of the trial. Steers were harvested (approx. 567 kg BW) and carcass data were collected after a 48 h chill. Four steers from the STD and STD+PHY diets ( $n=8$ ) were placed in metabolism stalls for collection of urine and feces during the last period. In Exp. 1, total ammonium N was decreased with PHY addition to the normal corn diet, but was increased with PHY addition to HAP corn diets, creating an interaction ( $P < .05$ ). There was a trend towards increased N retention and reduced N excretion with PHY addition. In Exp. 2, addition of PHY increased DMI and ADG, but reduced G:F ( $P < .05$ ). PHY inclusion reduced fecal Cu and S concentrations, but increased fecal propionate. In this study, PHY addition to a beef diet did not affect N or P digestibility. Trends observed in this beef study warrant further investigation with larger numbers of animals, especially in the areas of N retention/excretion and cation balance.

**Key Words:** Cattle, Excretion, Phosphorus

**201 Effects of dietary crude protein reduction on pig performance, manure composition, aerial ammonia, hydrogen sulfide, and odor levels in swine buildings.** B.E. Hill<sup>1</sup>\*, D.C. Kendall<sup>2</sup>, S.L. Hankins<sup>1</sup>, S.A. Trapp<sup>1</sup>, B.T. Richert<sup>1</sup>, D.T. Kelly<sup>1</sup>, A.L. Sutton<sup>1</sup>, G.L. Allee<sup>2</sup>, T.A. van Kempen<sup>3</sup>, and W.J. Powers<sup>4</sup>. <sup>1</sup>Purdue University, W. Lafayette, IN, <sup>2</sup>University of Missouri, Columbia, <sup>3</sup>North Carolina State University, Raleigh, <sup>4</sup>Iowa State University, Ames.

An experiment was conducted with grow-finish pigs ( $n=200$ ) to evaluate dietary crude protein reduction of swine diets to reduce aerial pollutants and nutrient excretion. Pigs (initial BW=92.3 kg) were placed in two identical, environmentally controlled rooms (5 pigs/pen, 5 pens/room; 50 pigs/rep) with treatments rotating between rooms. Diets were fed for

4 weeks and consisted of either a control, corn-soybean diet (13.1% CP, .52% true ileal digestible lys (TIDLys) for the barrows and 14.2% CP, .59% TIDLys for the gilts; CONT) or a reduced CP diet with supplemental synthetic amino acids (9.7% CP, .52% TIDLys for the barrows and 10.6% CP, .59% TIDLys for the gilts; LCP). Aerial ammonia concentration (AAC), hydrogen sulfide (HS), and detection threshold of odor (DT) samples were taken at wk 2 and 4 from both room and exhaust air. Ultrasound measurements and manure samples were collected at wk 0 and 4. Pigs fed CONT or LCP diets had similar overall ADG (790 vs. 784 g/d), overall G:F (.304 vs. .297), and ADFI (2601 vs. 2649 g/d). Pigs fed LCP had greater wk 4 loin depth (75 vs. 72 mm;  $P < .019$ ), numerically higher backfat thickness (17.9 vs. 16.9 mm) and greater total loin depth increase (11.9 vs. 9.4 mm;  $P < .003$ ). By wk 4, there was a 60.4% reduction in AAC ( $P < .04$ ) from room air and 52.2% reduction in the exhaust air AAC (13.4 vs 28.1 ppm;  $P < .0003$ ) when pigs were fed LCP diets. At wk 4, the stored manure from pigs fed LCP diets had 29.80% less total-N ( $P < .0001$ ), 30.6% lower ammonium-N ( $P < .0001$ ), 35.8% less total-N accumulation in the manure ( $P < .01$ ), and a lower manure pH (7.25 vs. 7.61;  $P < .0001$ ). The LCP diet was effective at reducing AAC, manure N, and manure pH while increasing final loin depth. In addition, if adequate amino acid levels are included in the diet, growth performance is comparable to a diet without synthetic amino acids.

**Key Words:** Pig, Odor, Manure Composition

**202 Nutrient Composition of Swine Lagoons and Hoop Barn Manure.** J.M. DeRouchey\*, J.R.D. Goodband, J.L. Nelssen, M.D. Tokach, S.S. Dritz, and J.P. Murphy, *Kansas State University, Manhattan.*

In accordance with state law, Kansas producers had designed nutrient management plans and applied manure to their fields using book values for swine manure composition. Concern was raised that these values are not applicable for all types of operations. This study was designed to determine the impacts of production phase and season of the year on the nutrient levels in swine manure. A total of 236 lagoon and 35 hoop barn manure samples were collected. Starting in February, 2000, lagoon samples were collected and analyzed every two months from five different types of production systems (sow, nursery; wean-to-finish, finish, and farrow-to-finish with a total of 9, 8, 7, 10, and 8 lagoons sampled, respectively). Manure from hoop barns (finishing only) also was collected and analyzed. Sampling technique and time of sampling each month was uniform across all sites. Average concentrations for total N and P were 1,402 and 204 ppm, respectively; however, the variation in concentration was great for both N (SEM=420) and P (SEM=80). Lagoon effluent from finishing (1,820 ppm) and wean-to-finish (1,852 ppm) lagoons had greater ( $P < 0.05$ ) N compared to sow (967 ppm) and farrow-to-finish (810 ppm) lagoons. Phosphorus in farrow-to-finish (106 ppm) lagoons was lower ( $P < 0.05$ ) than in wean-to-finish (302 ppm) lagoons. For seasonal characteristics, total N decreased (linear,  $P < 0.05$ ) from February (1,571 ppm) until December (1,241 ppm) with the largest decline occurring between June (1,635 ppm) and August (1,239 ppm). Phosphorus also was influenced by season (quadratic,  $P < 0.05$ ) with the highest levels occurring during June (287 ppm) and August (240 ppm) and the lowest during February (152 ppm) and December (212 ppm). For hoop barn manure, average concentrations for total N and P were 8,678 and 4,364 ppm, respectively. Therefore, season and type of production phase affects the nutrient content of swine lagoons. As a result of this project, Kansas producers are using individual analyses from their lagoons when developing nutrient management plans.

**Key Words:** Swine Lagoons, Hoop Barn, Nutrient Management

**203 Infrared spectroscopy as an optical nose for predicting odor sensation.** T.A.T.G. van Kempen<sup>1</sup>, W.J. Powers<sup>2</sup>, and A. Sutton<sup>3</sup>. <sup>1</sup>North Carolina State University, <sup>2</sup>Iowa State University, <sup>3</sup>Purdue University.

Quantifying odor is important for objectively assessing the impact of animal production systems on surrounding areas. A possible method that has received little attention is mid infrared spectroscopy (FTIR). Gases that contribute to odor have a unique infrared spectrum, and the advantage of FTIR over electronic noses or gas chromatography is that theoretically all these gases can be analyzed instantaneously. To determine the feasibility of FTIR for predicting odor, 27 air samples analyzed

by olfactometry were scanned in a Magna 760 FTIR spectrometer (Nicolet, Madison, WI) using an 84-meter path length gas cell. Scans were obtained over a period of about one minute and from 4000 to 740  $\text{cm}^{-1}$  with a resolution of 0.5  $\text{cm}^{-1}$ . Spectral data were correlated with olfactory data using partial least squares regression with full cross-validation (using The Unscrambler, Camo, Trondheim, No). Air samples were obtained from experiments with pigs fed diets formulated to alter odor emission. Due to low ventilation rates (15  $\text{m}^3/(\text{pigplacehour})$ ), high odor intensities were obtained, averaging  $997 \pm 585$ , with a range from 248 to 2161. Using these samples, a prediction error for odor sensation of 461 odor units ( $r^2=0.36$ ) was obtained. It is estimated that the measurement error of olfactometry is 300 units which limits the  $r^2$  of any method to approximately 0.75. Thus, this calibration, even though it is based on a small number of samples, is encouraging. By adding 23 samples collected under production conditions the prediction error could be further improved to 373 ( $r^2=0.51$ ) but the use of two sources of samples may affect the validity of this calibration. In conclusion, FTIR shows promise as an optical nose, but its true potential needs to be tested with a large number of field samples.

**Key Words:** Infrared, Odor, Swine

**204 Odor solutions initiative manure pit additive testing results.** C. L. Tengman<sup>\*1</sup>, R. N. Goodwin<sup>1</sup>, A. K. Gralapp-Gonzalez<sup>1</sup>, A. J. Heber<sup>2</sup>, J. Q. Ni<sup>2</sup>, K. J. Fakhoury<sup>2</sup>, and A. L. Sutton<sup>2</sup>, <sup>1</sup>National Pork Board, Des Moines, IA, <sup>2</sup>Purdue University, West Lafayette, IN.

Thirty-five manure storage pit additive odor control products were evaluated in triplicate. Each product was tested in an enclosed 15-inch

diameter by 48-inch tall cylinder. The test cylinders were located in an environmentally controlled room where the temperature was held at 20°C. Each cylinder was continuously ventilated with 7 Lpm of odor-free air. Periodic manure and product additions were made throughout the 42-day trials. Manure added to the cylinders was collected from a commercial swine grow-finish farm with a shallow pit manure system. All products were tested as prescribed by the vendors. Ammonia and hydrogen sulfide emissions from each cylinder were measured automatically several times a day. Air samples were collected four times during each trial and evaluated for odor concentration using olfactometry. Initial and final manure characteristics were also analyzed. Product effectiveness was determined by comparing odor, hydrogen sulfide, and ammonia measurements in treated cylinders against measurements in untreated cylinders. Statistical analysis provides measures of probability of differences in product activity. Results are reported at 75% and 95% levels of certainty. At 95% certainty, 0 products were found to reduce odor, 7 reduced hydrogen sulfide up to 47%, and 8 reduced ammonia up to 15%. At 75% certainty, 4 products reduced odor up to 32%, 3 reduced hydrogen sulfide up to 19%, and 4 reduced ammonia up to 3%. Overall, 20 products had a positive affect on reducing one of the three air emissions measurements.

**Key Words:** Odor Control, Pit Additives, Manure Additives

## Physiology

**205 Effects of estradiol (E) and pregnant mare serum gonadotropin (PMSG) on follicular growth in neonatal pigs.** P. E. Davis<sup>\*</sup> and M. C. Lucy, University of Missouri-Columbia.

Previously we found that pigs treated with E had fewer primordial follicles but equivalent numbers of growing follicles compared to control. We hypothesized that follicles initiated growth in response to E but failed to continue growth because of E-induced reduction of FSH. To test our hypothesis five-day-old piglets ( $n=31$ ) were treated in a two by two factorial design: T1, E (two-24 mg E implants) and PMSG (10 iu/kg injected twice weekly); T2, sham implanted and PMSG; T3, E implants and saline injection; and T4 (control) sham implanted and saline injection. Blood was sampled weekly and ovaries were collected on d 45 of treatment. Pigs treated with E had greater serum E than control (213 vs. 6 pg/ml; SEM=22;  $P<.001$ ). There was a main effect of E ( $P<.001$ ) and a tendency for an effect of PMSG ( $P<.10$ ) for combined ovarian weight (0.24 .01, 0.18 .01, 0.23 .01, and 0.15 .01 g for T1 to T4). Histological follicle classifications were: primordial [oocyte with no cuboidal granulosa cells (CGC)]; F0-1 (oocyte with CGC and flattened granulosa cells); F1 (oocyte with one complete layer of CGC); F1-2 (oocyte with more than one layer of CGC, but not two); and F>2 (oocyte with more than two layers of CGC). There was a main effect of E ( $P<.001$ ) and PMSG ( $P<.005$ ) for primordial follicles because E decreased the number of primordial follicles whereas PMSG increased the number of primordial follicles per field (38.2 8.0, 95.6 7.4, 29.1 8.0, and 53.4 8.0 for T1 to T4). There was also a main effect of E on growing follicles (F0-1, F1-2, and F>2) because E decreased the number of F0-1 (52 vs. 82; SEM=6;  $P<.001$ ), F1-2 (15 vs. 34; SEM=4;  $P<.001$ ), and F>2 (.2 vs. 3.7; SEM=.8;  $P<.01$ ) follicles per section. E did not affect the number of F1 follicles. PMSG did not affect the number of growing follicles (F0-1, F1, F1-2, and F>2). In summary, E increased ovarian weight while reducing the number of primordial and growing follicles. PMSG increased the number of primordial follicles and had no effect on growing follicles in either T1 or T2 pigs.

**Key Words:** Pig, Follicle, Estradiol

**206 Effect of PG600 given at d 7 post-weaning on follicular development, estrus, and ovulation in sows classified as anestrus in a commercial swine herd.** C.J. Bracken<sup>\*</sup>, J.S. Seaman, T.J. Safranski, and M.C. Lucy, University of Missouri.

PG600 (400 units PMSG and 200 units hCG, Intervet, Millsboro, DE) is given to induce estrus and ovulation during the period of seasonal anestrus. The objective of this study was to examine follicular dynamics and the relationship between estrus and ovulation in sows not observed in estrus by d 7 post-weaning and treated with either PG600 or saline (control). The study was conducted at a commercial swine farm in Marshall, MO during August 2001. Sows ( $n=57$ ) were weaned in three groups at 15.2 0.3 d after farrowing. Sows that did not exhibit estrus by d 7 post-weaning were randomly assigned to receive a 5 mL IM injection of either PG600 ( $n=28$ ) or saline ( $n=29$ ). Transrectal ultrasonography was performed once daily beginning on the day of treatment (d 0) and continued for 6 d. Follicular diameter was measured and time of ovulation was recorded. Estrus detection was performed once daily using fenceline boar contact. There was an effect of group on follicular diameter ( $P<.01$ ) because follicles were smaller for group 1 (4.2 0.2 mm) compared to groups 2 (4.8 0.1 mm) and 3 (4.7 0.2 mm). Follicles in PG600 and saline treated sows had similar diameter on d 0 (4.0 0.1 mm vs. 4.2 0.1 mm). By d 6, follicular diameter had increased for PG600 sows but not saline sows (6.0 0.2 mm vs. 4.1 0.1 mm;  $P<.001$ ). Greater follicular development in PG600 sows was associated with an increase in percentage of sows in estrus ( $P<.001$ ) and percentage of sows ovulating within 6 d ( $P<.001$ ) for PG600 (93.1 and 72.4%) compared to saline (32.1 and 10.7%). The treatment by group interaction was not significant for percentage of sows in estrus or ovulating. Treatment to estrus interval (3.7 0.3 d) and estrus to ovulation interval (2.0 0.1 d) were similar for PG600 and saline sows. We conclude that summertime PG600 treatment of anestrous sows at d 7 post-weaning increases follicular development and the number of sows expressing estrus and ovulating within 6 d of treatment.

**Key Words:** PG600, Sow, Anestrus

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**Key Words:** PG600, Sow, Anestrus



**207 Failure of endogenous follicle-stimulating hormone (FSH) to stimulate early ovarian growth in prepubertal gilts.** J. J. Ford\*, T. H. Wise, and R. K. Christenson, *USDA, ARS, RLH US Meat Animal Research Center.*

Prepubertal gilts of three genetic lines selected for increased ovulation rate have greater plasma FSH concentrations (10 - 25%) than observed in gilts of respective control lines (Cassady et al., 2000; Ford et al., 2001). The objective of the current study was to determine if ovarian weights at 85 d of age were influenced by endogenous FSH. Gilts from a line selected for greater number of corpora lutea (OR, n = 137) and from the control line (CO, n = 138) were bled at 65 and 75 d of age. At 85 d of age, gilts were moved to preoperative pens in a surgery facility. Blood samples were collected followed by high lumbar laparotomy and removal of one ovary. Side of ovariectomy was alternated within littermate gilts. The study was conducted in spring and fall seasons. Body weight was greater ( $P < 0.05$ ) in CO than in OR gilts at 56 and 154 d of age. Plasma FSH concentrations, determined by radioimmunoassay, were 19% greater ( $P < 0.001$ ) at 65 d of age and 13% greater ( $P < 0.001$ ) at 75 d of age in OR than in CO gilts. Ovarian weight (range 0.05 - 2.34 g) was slightly heavier ( $P < 0.09$ ) on the left than on the right side (0.68 vs 0.40 g). Plasma FSH concentrations at 85 d (3.6 vs 3.7 ng/mL) and ovarian weight (0.47 vs 0.46 g) were similar in CO and OR gilts, respectively, but ovarian weight was correlated negatively with plasma FSH concentration ( $r = -0.29$ ,  $P < 0.01$ ). Ovarian and 56-d body weight were not affected ( $P > 0.2$ ) by season. For gilts in the first season, pubertal age was similar ( $P > 0.5$ ; 206 vs 203 d) in the two lines; luteal phase ovarian weight adjusted for number of corpora lutea was heavier ( $P < 0.05$ ) in OR than in CO gilts. Puberty and ovarian weight data are being collected for gilts in the second season. FSH concentration and negative correlation of FSH with ovarian weight indicate that negative feedback control of FSH secretion by the ovaries is operative at 85 d of age in both lines. In addition, ovarian weight prior to 85 d of age is not stimulated by the greater circulating FSH in OR gilts observed on d 65 and 75.

**Key Words:** Ovulation, FSH, Ovary

**208 The effect of progesterone treatment on day 2 and 3 of pregnancy on gestation length, litter size, birth weight, and piglet growth rate in intact white crossbred pigs.** J. L. Vallet\*, *USDA, ARS, RLH US Meat Animal Research Center.*

Previous results indicated that treatment of unilaterally hysterectomized-ovariectomized white crossbred gilts on d 2 and 3 of pregnancy with exogenous progesterone increased fetal weights at 105 d of gestation and decreased uterine capacity. Because the incidence of stillbirths is associated with underweight piglets, the objective of the current experiment was to determine whether early progesterone treatment could be used to decrease the number of stillborn pigs per litter in intact white crossbred gilts. Gilts were mated at estrus and received either no treatment (n=78) or progesterone injection (200 mg/d, i.m.; n=34) on d 2 and 3 of pregnancy. Gilts were then allowed to farrow and gestation length, number of fully formed piglets, number born alive, and birth weights were recorded. Piglets were weighed again at weaning (approximately 21 d) and at approximately 56 d of age. Progesterone-treated gilts did not differ from control-treated gilts in the number of fully formed piglets ( $9.44 \pm 0.43$  and  $10.18 \pm 0.29$ , respectively) and number of piglets born alive ( $8.76 \pm 0.45$  and  $9.4 \pm 0.3$ , respectively), resulting in no difference in the number of stillborn piglets per litter ( $0.68 \pm 0.19$  and  $0.78 \pm 0.13$ , respectively). Progesterone treatment shortened ( $P=0.05$ ) gestation length ( $115.47 \pm 0.21$ ) compared to control ( $115.97 \pm 0.14$ ). Piglet birth weight for progesterone-treated gilts did not differ from piglet birth weight for control gilts ( $1.60 \pm 0.04$  and  $1.57 \pm 0.03$  kg, respectively; analyzed both before and after adjusting for number of fully formed piglets), weaning weight ( $5.43 \pm 0.14$  and  $5.13 \pm 0.09$  kg, respectively; analyzed after adjusting for actual day of weaning and number weaned) and weight at 56 d of age ( $17.07 \pm 0.47$  and  $16.46 \pm 0.30$ , respectively; analyzed after adjusting for actual day weighed). These results indicate that early progesterone treatment shortens gestation length but has no effect on litter size in intact pigs. Furthermore, progesterone treatment does not affect birth weights of the piglets, the number of stillborn piglets or the subsequent growth rates of piglets born alive.

**Key Words:** Progesterone, Stillbirth, Fetus

**209 Altering sperm membranes to improve cryosurvival.** J.K. Graham\* and P.H. Purdy, *Colorado State University.*

Damage can occur to sperm at any step during cryopreservation, however, sperm are particularly vulnerable when undergoing freezing itself and when cryoprotectants are removed. Cell damage at these steps may be ameliorated if membrane permeability fluidity were increased. Experiments were conducted to alter sperm membrane composition to improve cell cryosurvival. Cyclodextrins pre-loaded with cholesterol (CLC) were added to bull sperm to increase the cholesterol level in the sperm plasma membrane. Initial experiments optimized this procedure by monitoring sperm motility after cryopreservation. Sperm treated with 0, 0.75, 1.5, 3.0, 4.5, 6.0 or 7.5 mg CLC resulted in 42, 58, 60\*, 57, 54, 53 and 48% motile cells, respectively, after thawing (\* different from control at  $P < 0.05$ ). When 120 million sperm were treated with 0, 0.75, 1.5, 3.0 and 6.0 mg of cyclodextrin that were pre-loaded with fluorescently labeled cholesterol, 0, 0.0625, 0.0875\*, 0.1125\* and 0.1475\*  $\mu$ M of cholesterol, respectively, were detected in the samples. Additional experiments, utilizing flow cytometry indicated that all sperm within a single treatment contained similar levels of cholesterol. Addition of cholesterol to the sperm altered membrane physiology, by making the plasma membrane more permeable to glycerol. When control and CLC treated sperm were cryopreserved and used to fertilize bovine oocytes, in vitro, similar percentages of oocytes were fertilized 48 and 46%, when equal numbers of live sperm were added. Finally, when 32 heifers/treatment were inseminated with 750,000 total cryopreserved sperm, pregnancy rates were 50 and 59% for control and CLC treated sperm. Increasing the cholesterol content of bull sperm membranes alters sperm membrane physiology permitting greater numbers of cells to survive the cryopreservation process. In addition, CLC treated sperm are capable of fertilizing oocytes in vitro and in vivo. Finally, such treatment may be able to improve the fertilizing potential of frozen semen and/or permit fewer spermatozoa to be used in an insemination dose. Supported by USDA 2000-02410 and NAAB.

**Key Words:** Cryopreservation, Cholesterol, Spermatozoa

**210 Interaction of bovine sperm with oviduct cells modifies intracellular pH regulation of sperm.** J.J. Parrish\*<sup>1</sup> and C.M.O. Medeiros<sup>2</sup>, <sup>1</sup>*University of Wisconsin-Madison*, <sup>2</sup>*Universidade Federal do Rio Gande do Sul, Porto Alegre, RS, Brazil.*

As sperm move up the female reproductive tract they colonize the first portion of the oviduct isthmus by binding to epithelial cells. One of the important functions of sperm binding in the isthmus is that it prolongs sperm viability. In vitro, the ability of oviduct epithelial cells to prolong sperm viability also requires sperm binding. The mechanisms however by which sperm survival is prolonged have not been identified. We have investigated the effect of bovine sperm binding to bovine oviduct epithelial cells on the regulation of sperm intracellular pH ( $pH_i$ ). The  $pH_i$  of bovine sperm was determined by quantification of BCECF fluorescence in sperm loaded with acetoxymethyl ester of BCECF. Upon binding of sperm to oviduct epithelial cells, sperm  $pH_i$  at 0.5 hr was 6.700.02 and increased to only 6.750.01 by 6 hr. In contrast, sperm incubated in medium alone (control) had a  $pH_i$  of 6.740.02 at 0.5 hr and increased to 6.890.02 by 6 hr. The binding of sperm to oviduct epithelial cells prevented the increase in  $pH_i$  seen in control sperm during incubation ( $p < 0.05$ ). To better understand the regulation of sperm  $pH_i$ , the recovery of sperm  $pH_i$  after an intracellular alkalinization was fit to an exponential decay equation with a single rate constant. While the rate constant was not effected by sperm binding to oviduct cells ( $p > 0.05$ ), the instantaneous velocity of recovery as measured at pH 7.1 was greater for sperm bound to oviduct cells ( $p < 0.05$ ) at both 0.5 hr (294 vs 212 nmol H<sup>+</sup>/min) and 6hr of incubation (202 vs 52 nmol H<sup>+</sup>/min). The intracellular buffering capacity of sperm did not change relative to the control sperm at either 0.5 or 6 hr of incubation ( $p > 0.05$ ). The results support the activation of a sperm acidification mechanism upon binding of bovine sperm to oviduct cells. Bovine sperm  $pH_i$  is lower than the medium sperm are bathed in either in vitro or in vivo. Unless an acidification mechanism is activated, the  $pH_i$  of sperm will gradually increase upon incubation either in vivo or in vitro. Increases in sperm  $pH_i$  are known to be associated with sperm activation, capacitation and their

eventual death. Preventing the inevitable increase in  $pH_i$  by activating an acidification mechanism would then prolong the viability of sperm.

**Key Words:** Bovine Sperm, Female Reproductive Tract, Sperm Physiology

### **211 Commercial application of mammalian sperm sexing.** D.L. Garner\* and G.E. Seidel, *Colorado State University*.

The process of sexing mammalian sperm by flow cytometry has been progressively developed over the last 20 years, and now is being commercialized. This sexing process, which is based on DNA content differences between X- and Y-chromosome-bearing sperm, utilizes the DNA-specific bisbenzamidine dye, Hoechst 33342 to accurately measure the DNA content of stained sperm with a flow cytometer/flow sorter. Stained bovine sperm can be sorted routinely at rates of about 5,000 live sperm of each sex/sec at 90% accuracy. About 80% of those sorted can be recovered for use, resulting in production of around 15 million live sperm of each sex per machine per hour. Sex-sorted bovine sperm usually are packaged in 0.25-ml straws at 1.5 to 3 million sperm/dose and cryopreserved for later use. More than 10,000 heifers have been bred with sex-sorted, cryopreserved bovine sperm, resulting in pregnancy rates of 50% in well-managed herds in which pregnancy rates are about 70% with unsexed control sperm. There is little information available about the use of sexed sperm with high-producing dairy cows. Sexing accuracy is routinely about 90% for the selected sex. The economic issues of commercial application of this technology to cattle and other domesticated species are yet to be determined.

**Key Words:** Flow Cytometry, Fertility, DNA Content

### **212 Sexual dimorphism among blastocysts may provide for sex ratio adjustment in the bovine.** R. M. Roberts\*, K. Kimura, and M. Larson, *University of Missouri-Columbia*.

In species that live in socially structured herds or flocks, females in good body condition or of high social rank produce more male offspring than females. Increased dietary energy appears to be the factor that skews the sex ratio in favor of males. Although the situation is less clear in cattle, the sex ratio of males to females becomes significantly greater than 1:1 where herd nutritional status is high. One means of discriminating between sex of embryos could arise if one sex signaled its presence to the mother more robustly than the other. Alternatively, the environment of the reproductive tract might favor embryos of one sex over the other. Here we discuss two kinds of sexual dimorphism in bovine embryos that might allow cows to adjust the sex ratio of calves borne. The first is in the production of interferon-tau (IFN-tau), a protein secreted by trophectoderm and responsible for preventing the regression of the CL during early pregnancy. We show that expanded female blastocysts produce about twice as much IFN as males. Since male blastocysts release less, rather than more, IFN-tau than females and do not appear to produce it earlier, it is unlikely that the strength of IFN signaling can account for the greater success of male embryos in establishing a pregnancy in cows on a high plane of energy nutrition. A second form of polymorphism is the superior ability of male in vitro produced bovine embryos to survive in a glucose-rich medium. Glucose concentrations in the reproductive tract are low following implantation but rise with the onset of the luteal phase. Such a change may be accelerated in well-fed cows, thereby providing male embryos with a survival advantage. We speculate that these differences between the sexes are manifestations of phenomena that occur naturally in vivo and could provide plasticity in embryo selection during the establishment of pregnancy. The higher production of IFN-tau by female blastocysts may offset some of the advantages males have to survive a nutrient rich, and potentially hostile uterine environment.

**Key Words:** Interferon-Tau, Glucose, Pregnancy

### **213 A review of the estrous cycle in beef cattle: Physiology, endocrinology, and follicular waves.** F. N. Kojima\*, *University of Missouri, Columbia*.

Estrus synchronization is a valuable tool to enhance reproductive management in beef cattle. Procedures that can: 1) facilitate synchronization of estrus in cycling cattle; and 2) induction of an ovulatory estrus in peripubertal heifers and postpartum anestrous cows, will increase reproductive rates and expedite genetic progress through use of artificial

insemination (AI). Managing reproduction in beef cattle requires a thorough understanding of changes in physiology and endocrinology that occur during the estrous cycle and the transition from anestrus to cyclicity. Successful reproductive management requires the successful application of available knowledge to current estrus synchronization protocols. To that end, this review will cover the basic physiology and endocrinology of the estrous cycle, provide an overview of our current understanding of follicular waves, and address considerations related to anestrus. Topics to be covered that will specifically address basic physiology and endocrinology of the estrous cycle include: 1) follicular development; 2) endocrinology associated with follicular development; 3) corpus luteum development and regression; 4) endocrinology associated with corpus luteum function; and 5) a summary of the estrous cycle. Consideration of anestrus will specifically relate to conditions that include: 1) the prepubertal and peripubertal period in heifers; and 2) the postpartum period in cows. Various available estrus synchronization protocols utilize several key components, such as prostaglandin  $F_{2\alpha}$ , GnRH, and progestins. This review will include an overview of these components and their applications. A better understanding of physiology and endocrinology of the estrous cycle will improve reproductive management of beef cattle and facilitate the successful application of estrus synchronization protocols. This, in turn, will increase use of AI and hasten genetic improvement in beef cattle production systems.

**Key Words:** Estrous Cycle, Beef Cattle, Estrus Synchronization

### **214 Synchronization of estrus in beef heifers with MGA and PGF.** D.J. Kesler\*, N.R. Wherley, and D.B. Faulkner, *University of Illinois*.

Considerable research has been done to develop an consistently efficacious procedure to synchronize estrus in beef heifers. The MGA/PGF procedure has emerged as the procedure of choice; however, the original procedure required the detection of estrus for breeding. In a survey of beef producers, we have found that the major reason beef producers do not use synchronize estrus is the lack of time and labor. When given a choice between using a procedure that requires breeding upon estrus detection or at a predetermined time, 85% chose timed AI. The MGA/PGF procedure involves the feeding of 0.5 mg of MGA/heifer/day for 14 consecutive days followed by an injection of PGF 19 days after the last day of MGA feeding. Although an interval of 17 days to a timed AI was previously used, the 19 day interval reduces the variability to estrus (Lamb et al., *Theriogenology* 53:691, 2000). Intervals of less than 17 days result in poor synchronization (Kesler et al., *J. Anim. Sci.* 74:2885, 1996). In addition to synchronizing estrus in estrus-cycling heifers, the procedure hastens and synchronizes fertility in prepubertal heifers (Imwalle et al., *Biol. Reprod.* 58:1432, 1998). We have conducted a field study with approximately 1,500 heifers. All heifers were synchronized with the MGA/PGF procedure with a 19 day interval from MGA to PGF. Producers then bred the heifers using two of three methods permitting two comparisons: breeding at estrus vs. timed AI at 72 h and timed AI at 72 h vs. timed AI at 60 h along with an injection of GnRH. Results from these studies will be presented and suggest that timed AI may be used with the efficacious MGA/PGF procedure to synchronize estrus with equal or better results than breeding at estrus.

**Key Words:** MGA, PGF, Estrus

### **215 A review of methods to synchronize estrous cycles of postpartum suckled beef cows with the oral progestin, melengestrol acetate.** D. J. Patterson\*, *University of Missouri, Columbia*.

This review will consider recently developed methods to control estrous cycles of postpartum beef cows with melengestrol acetate (MGA). Melengestrol acetate is an orally active progestin that will suppress estrus and prevent ovulation in cattle when consumed on a daily basis. The duration of feeding may vary among the various protocols that are available, but the level of feeding ( $.5 \text{ mg} \cdot \text{cow}^{-1} \cdot \text{day}^{-1}$ ) is consistent and critical to success. Feeding MGA for 14 days followed by injection of prostaglandin  $F_{2\alpha}$  (PG) 17 to 19 days after MGA withdrawal was developed as an effective method of estrous cycle control for heifers (Brown et al., 1988; Lamb et al., 2000). Studies in postpartum beef cows identified significant improvements in specific reproductive endpoints among cows that received MGA prior to the administration of PG compared with cows that received PG only, including increased estrus response and improved synchronized conception and pregnancy rates (Patterson et al.,

1995). Recently, an improvement in synchrony of estrus was reported without compromising fertility in postpartum beef cows that were pretreated, either short- or long-term, with MGA prior to GnRH and PG. We proposed the general hypothesis that progestin (MGA) treatment prior to the GnRH-PG estrus synchronization protocol would successfully: 1) induce ovulation in anestrous postpartum beef cows; 2) reduce the incidence of a short luteal phase among anestrous cows induced to ovulate; 3) increase estrus response, synchronized conception and pregnancy rates; and 4) increase the likelihood of successful fixed-time insemination. Protocols that utilize this sequential approach to estrous cycle control include the MGA<sup>®</sup> Select (Wood et al., 2001) and 7-11 Synch (Kojima et al., 2000) protocols. Modified programs that utilize the GnRH-PG protocol with MGA feeding between injections have also been included. The flexibility in matching specific protocols with the particular management system involved is a major advantage in using MGA to control estrous cycles in beef cows.

**Key Words:** Estrus Synchronization, Progestin, Beef Cows

## 216 Synchronization of estrus in beef cows and beef and dairy heifers with EAZI-Breed Cattle CIDR Inserts (intravaginal progesterone inserts) and Lutalyse Sterile Solution. John R. Chenault\*, *Pharmacia Animal Health*.

EAZI-Breed<sup>TM</sup> Cattle CIDR<sup>®</sup> Inserts are T-shaped intravaginal inserts consisting of silicone containing 10 % progesterone by weight molded over a nylon spine. Inserts are administered for 7d with an injection of Lutalyse<sup>®</sup> Sterile Solution administered on day 6. Progesterone from the insert suppresses estrus and ovulation in cattle that spontaneously regress their corpus luteum (CL) during the administration period; upon insert removal these animals express a synchronized estrus. Lutalyse is used to synchronize estrus in cattle with a functional CL at the end of the insert administration period. Therefore, when used together estrus can be synchronized in all estrous cycling cattle. Multi-location studies have been conducted with beef cows (6 locations), beef heifers (5 locations) and dairy heifers (4 locations). (Lucy et al JAS 79:982:2001) These studies indicate that estrus is effectively synchronized with this treatment regimen. Animals inseminated following removal of inserts had conception rates comparable to that observed in contemporary controls. In addition, estrus was advanced in about 50 % of non-cycling beef cows and heifers. Induced estruses had fertility comparable to that observed in estrous cycling contemporary controls. This treatment regimen may not be acceptable for use with timed AI because follicular development is not controlled resulting in estrus distributed over 2 to 3 days. The following treatment regimen has been evaluated in beef cows with fixed time AI; 100 mcg GnRH at the time of insert administration, 7 days later insert removal and Lutalyse injected, and 100 mcg GnRH and AI 48 hours after insert removal. Pregnancy rate to fixed time AI was improved in beef cows with inserts administered relative to that observed in beef cows with the same treatment regimen without the insert (Co-Synch program). (Lamb et al JAS 79:2253:2001) However, increased pregnancy rate has not been observed consistently across studies. (Johnson et al; JAS 78: Supp 1:218:2000).

**Key Words:** Estrus Synchronization, Beef Cows and Heifers, CIDR Inserts

## 217 Incidence of postpartum anestrus in suckled beef cattle: Treatments to induce estrus, ovulation and conception. J.S. Stevenson\* and S.K. Johnson, *Kansas State University*.

Early herd conception is limited by the proportion of cows that have resumed normal estrous cycles (CYC) at the beginning of the breeding season. In 2,892 beef cows studied, only 55% were CYC before the breeding season. Body condition (BC), parity, and days postpartum (DPP) influenced the proportion of CYC as assessed by concentrations of blood progesterone. As BC increased from <4 to ≥5.5 (1 = thin and 9 = fat), CYC increased linearly ( $P < 0.001$ ) by  $16 \pm 1\%$  for each unit increase in BC. Cyclicity increased linearly ( $P < 0.001$ ) from 34% (<50 d) to a peak of 66% after 80 DPP. For every 10-d interval from <50 to >80 d, CYC increased ( $P < 0.05$ ) by  $6 \pm 0.5\%$ . Compared to older cows, fewer (LS constant =  $-22 \pm 2\%$ ;  $P < 0.01$ ) 2-yr-old cows were cycling, despite calving up to 3 wk earlier. Ovulation was induced in noncycling cows after injection of GnRH or GnRH plus progestin (7-d norgestomet [NORG] implant, 7-d CIDR, 14-d feeding of melengesterol acetate [MGA] ending

12 d before GnRH). In noncycling cows, percentages of ovulation induction were: 46% after an injection of GnRH; 73% after GnRH + CIDR; 19% after GnRH + NORG; 79% after MGA preceding GnRH; and 21% after PGF<sub>2α</sub> (PGF) alone (control). Ovulation induction was limited in 2-yr-old cows until BC scores were ≥5.0. Induction of ovulation increased linearly ( $P < 0.05$ ) by  $8.4 \pm 2\%$  for each unit increase in BC. Expression of estrus in noncycling cows treated with GnRH + NORG + (PGF 7 d after GnRH; 53%) was greater ( $P < 0.001$ ) than in those treated with GnRH + (PGF 7 d after GnRH; 25%) or controls treated with only PGF (15%). Conception after AI based on detected estrus or timed AI at 48 h after PGF increased ( $P < 0.05$ ) quadratically with advancing DPP. Among noncycling cows, conception rates were: 36% after GnRH + PGF; 49% after GnRH + CIDR + PGF; 48% after GnRH + NORG + PGF; 0% after MGA preceding GnRH + PGF; and 18% after PGF alone. Anestrous suckled cows responded best to treatments that included GnRH plus a short-term progestin to maximize ovulation induction before PGF, and expression of estrus and conception after PGF.

**Key Words:** Anestrus, GnRH, Progestin

## 218 Past, Present, and Future impact of ultrasound technology on beef cattle reproductive research and management strategies. G. C. Lamb\*<sup>1</sup> and C. R. Dahlen<sup>1</sup>, <sup>1</sup>*University of Minnesota*.

The area that has arguably benefited more from the development of ultrasound technology than any other area is reproduction in large animals. Ultrasonography is now commonly used for fetal sexing and early embryonic detection. Ultrasound offers researchers the ability to visually characterize the uterus, fetus, ovary, corpus luteum, and follicles and has been used to monitor the growth and atresia of individual antral follicles, which usually takes place in two or three waves during the estrous cycle. Ultrasonographically classified follicle stages have also shown to be correlated closely with the ability of follicles to produce hormones (estrogen:progesterone and estrogen:androstenedione ratios, inhibin concentrations, and IGF-binding proteins) indicative of follicular health. We recently determined by ultrasound that the diameter of the ovulatory follicles prior to the second injection of GnRH in a CoSynch estrous synchronization system was related to overall pregnancy rates. Cows that had follicles >12 mm had greater ( $P < 0.01$ ) pregnancy rates than those with follicles ≤ 12 mm. In addition, cows that had follicles from 16.0 to 17.9 mm had the greatest ( $P < 0.01$ ) pregnancy rates. With ultrasonography we determined the incidence of embryonic loss in beef cows from d 25 of gestation to day 45 to be 6.5%, whereas, we noted a 4.2% incidence of embryonic loss in beef heifers initially ultrasounded at day 30 of gestation and subsequently palpated rectally at between day 60 and 90 after insemination. Fetal sexing is fast becoming a common management tool in beef cattle enterprises with accuracy in sex determination exceeding 97%. The applications of ultrasound used by scientists include the ability to monitor follicular characteristics, ovarian function, and aid in follicular aspirations and oocyte retrieval. In the future, as technology improves technicians will have an opportunity to use the internet or video conferencing for ultrasound image analyses. With every new technological development, scientists, veterinarians, and producers discover new possibilities for the use of reproductive ultrasound to enhance the scientific merit of research or improve reproductive efficiency in cattle operations.

**Key Words:** Ultrasound, Beef Cattle, Embryonic Loss

## 219 Factors affecting fertilization in estrus-synchronized cattle. R. G. Saacke\*, *Virginia Polytechnic Institute and State University*.

Pregnancy rate due to the inseminate, female population, and/or reproductive strategy employed is complex and often involves an interaction of the three. Fertilization failure or failure in embryogenesis, which comprise pregnancy rate, can both be of seminal origin alone. In addition, time of insemination in relation to manipulation of the female and resulting expression of estrus and time of ovulation also interact with seminal traits. This interaction appears to be at the level of sperm numbers accessing the ovum and post fertilization, affecting very early embryonic development. Clearly, males differ in the numbers of sperm required to reach maximum fertilization rate. Males requiring more sperm would be considered to have compensable seminal deficiencies. These include a number of known problems (viability and morphology

based) and unknown factors (functional and molecular traits) precluding sperm access to the ovum. Depressed fertility of an inseminate, independent of sperm dosage, would reflect presence of uncompensable deficiencies. These would be associated with the presence of fertilizing sperm that are incompetent to maintain the fertilization process or subsequent embryogenesis once initiated, with most failures occurring prior to maternal recognition of pregnancy. Such sperm would preempt fertilization by competent sperm. Chromatin aberrations in morphologically normal or near normal spermatozoa from abnormal semen samples appear to be the best candidates for uncompensable seminal deficiencies; however, more work is necessary in this area. Six-day-old non-surgically recovered bovine ova/embryos have been effective in their use to evaluate compensable and uncompensable seminal deficiencies as well as reproductive strategies, including time of insemination relative to ovulation. These ova/embryos provide information on fertilization status and embryo quality as well as quantitative and qualitative data regarding associated accessory sperm. Thus, they permit the separation of reproductive failure by fertilization (sperm access to the ovum) from that by embryonic development (competence of the fertilizing sperm and fertilized oocyte) in the pursuit of efficient reproductive strategies and the role of the male/inseminate in optimizing such strategies.

**Key Words:** Fertilization, Embryo Quality, Accessory Sperm

**220 Efficacy of Ovsynch and Ovsynch plus CIDR treatments on effecting a cure in dairy cows with cystic ovarian disease.** T.L. Steckler\*, T.F. Lock, G.C. McCoy, and D.J. Kesler, *University of Illinois*.

An experiment was conducted to determine if the inclusion of an intravaginal progesterone releasing insert (CIDR) during synchronization would improve pregnancy rates (PR) to a timed AI in lactating dairy cattle. The experiment included 57 primi- and multiparous lactating dairy cows from the University of Illinois Dairy Research Unit. The cows were assigned to a 2x2 factorial design with Ovsynch with or without CIDR and the presence (Cystic; n=20) or absence (Control; n=37) of cystic structures as the main effects. Cows were diagnosed per rectum to have a cystic ( $\geq 25$  mm) structure(s) present on one or both ovaries during scheduled herd health checks. Confirmation, 7 to 10 d later, of cystic structure(s) was performed on d -7 via ultrasonography. Cows were administered the Ovsynch protocol (100 g of GnRH on d -7, 25 mg of PGF on d 0, 100 g GnRH on d +2, AI 16 h after the last GnRH injection). CIDRs (1.9 g progesterone) were administered from days -7 to 0. Ovarian structures were monitored on days -7, +2, +7, +14, +21, and +28. Pregnancy was determined via ultrasonography on d +35 and +56 and palpation on d +84. Two cows were removed from the trial prior to d +35 and 3 after d +35 due to non-reproductive health reasons and were not included in any further analysis. PR for Controls+CIDR were 76%, 59%, and 53% vs 61%, 61%, and 56% for Controls on d +35, +56, and +84, respectively. PR for Cystic+CIDR were 44%, 44% and 44% vs 36%, 22%, and 22% for Cystic on d +35, +56, and +84, respectively. All (100%) Cystic+CIDR cows ovulated and formed a corpus luteum vs 82% of Cystic cows. A difference ( $P < 0.05$ ) was detected in the number of cows (no CIDR) with cystic structures on d +28 in Control and Cystic cows (5% vs 36%, respectively). However, when a CIDR was administered during synchronization no difference ( $P > 0.3$ ) was observed in the number of cows with cystic structures on d +28 (6% vs 22% in Control+CIDR and Cystic+CIDR, respectively). In summary, Ovsynch effects a cure in cows with cystic ovarian disease and the 28 d post-treatment incidence of ovarian cysts in cows administered Ovsynch+CIDR was similar to Control cows unlike cows administered Ovsynch alone.

**Key Words:** Cystic Ovarian Disease, CIDR, Ovsynch

**221 Synchronization of ovulation in suckled beef cows with GnRH-CIDR-PGF and timed insemination at 48 or 60 h after PGF<sub>2α</sub>.** S.K. Johnson\*, K.R. Harmony, and J.S. Stevenson, *Kansas State University*.

The objectives of this study were to compare intervals of 48 or 60 h between PGF and timed AI (TAI) and administration of GnRH or Saline at TAI in a GnRH-CIDR-PGF synchronization protocol. Cows from two herds were blocked by breed, calving date, and parity and assigned randomly to a 2 x 2 factorial arrangement of treatments: 1) TAI at 48 or 60 h after PGF; and 2) administration of GnRH or Saline at TAI.

Herd 1 (n=139) consisted of primiparous and multiparous Angus, Simmental, and Hereford cows. Herd 2 (n=212) consisted of multiparous, Angus-based, crossbred cows. All cows received 100 µg GnRH i.m. and a used intravaginal progesterone insert (CIDR) on d -7. On d 0, CIDRs were removed and PGF (25 mg) was injected i.m. Blood serum samples for progesterone (P4) analysis were collected on d -14, -7, 0, and at TAI. Cows with P4  $\geq 1$  ng/mL (HI) on d -14 and/or d -7 were assumed to have resumed normal estrous cycles (CYC) and cows with P4  $< 1$  ng/mL (LO) on d -14 and -7 were classified as non-cycling (NC). Pregnancy rate (PR) to TAI was determined on d 35-36 via transrectal ultrasonography. Cows inseminated at 48 or 60 h after PGF had similar PR (80/179; 45% vs. 87/181; 48%, respectively). GnRH at TAI tended ( $P = 0.12$ ) to increase PR compared to cows receiving Saline at TAI (90/178; 51% vs. 77/182; 42%). Cycling cows with HI P4 on d 0 and LO P4 at TAI had higher ( $P < 0.05$ ) PR if they received GnRH compared to Saline at TAI (49/86; 57% vs. 36/93; 39%, respectively). Treatment with GnRH or Saline at TAI did not influence PR in NC cows with HI P4 on d 0 and LO P4 at TAI (24/51; 47% vs. 28/49; 57%, respectively). Non-cycling cows with a P4 rise above baseline on d 0 of 0.4 to 0.9 ng/mL (CIDR effect ?) had greater ( $P < 0.03$ ) PR if GnRH was given at TAI compared to Saline (10/16; 63% vs. 5/19; 26%, respectively). Timed AI at 48 or 60 h after PGF in a GnRH-CIDR-PGF protocol was equally effective. Administration of GnRH at TAI improved conception in all CYC cows and in some NC cows depending on their P4 status.

**Key Words:** Timed Insemination, Beef Cows, GnRH

**222 Effect of handling intensity on blood acid-base balance in slaughter weight pigs.** T. M. Bertol\*<sup>1,2</sup>, M. Ellis<sup>1</sup>, D. N. Hamilton<sup>1</sup>, and F. McKeith<sup>1</sup>, <sup>1</sup>University of Illinois at Urbana-Champaign, IL, <sup>2</sup>CNPq, Brazil.

This study was carried out to investigate the impact of different handling intensities on blood acid-base balance in slaughter weight swine (140.62  $\pm$  9.75 kg). Pigs were moved individually through a handling facility (12.2 x 0.91 m) for six laps (up and down the passage), with or without the use of electric prods. Three treatments were compared involving different levels of the electric prod usage: 1) None (n = 3); 2) Moderate (three times per lap; n = 5); 3) Intense (five times per lap; n = 5). Blood was collected from the jugular vein one h before the handling test (HT) to establish baseline values (BLV), at the end of the HT, and at 2 h after the completion of the HT. The blood was analyzed for pH, lactate, PCO<sub>2</sub>, PO<sub>2</sub>, HCO<sub>3</sub>, TCO<sub>2</sub>, base excess, and SO<sub>2</sub> using an Automatic Clinical Analyzer (i-STAT Corporation, Princeton, NJ). BLV for blood parameters were similar ( $P > 0.05$ ) across all treatments. In addition, all blood parameters had returned to BLV and were similar ( $P > 0.05$ ) across treatments 2 hours after the end of the HT. Pigs that were moved without the use of electric prods showed limited changes ( $P > 0.05$ ) in blood parameters at the end of the HT relative to BLV. At the end of the HT, blood lactate was increased (7.58  $\pm$  1.39, 13.38  $\pm$  1.08, 18.83  $\pm$  1.08 mmol/L; for treatments 1, 2, and 3, respectively;  $P < 0.001$ ) and pH decreased (7.29  $\pm$  0.04, 7.17  $\pm$  0.03, 7.09  $\pm$  0.03;  $P < 0.01$ ) for pigs that were handled with electric prods. In addition, blood levels for HCO<sub>3</sub> (30.0  $\pm$  1.70, 29.4  $\pm$  1.32, 18.0  $\pm$  1.32 mmol/L;  $P < 0.001$ ), TCO<sub>2</sub> (31.7  $\pm$  1.81, 31.8  $\pm$  1.40, 19.8  $\pm$  1.40 mmol/L;  $P < 0.001$ ), and base excess (3.67  $\pm$  1.84, 0.80  $\pm$  1.42, -12.00  $\pm$  1.42 mmol/L;  $P < 0.001$ ) were reduced for pigs on the Intense compared to the other two treatments. The results of this study show large differences in blood parameters resulting from different intensities of animal handling suggesting that blood acid-base balance may be a useful index to monitor animal responses in research studies as well as under commercial conditions.

**Key Words:** Acid-Base Balance, Animal Handling, Pigs

**223 Survival of ram sperm stored at 39° C in ram semen diluter, caprogen or synthetic oviduct fluid.** S. Meredith\*, G. Dudenhoeffer, D.O. Kiesling, A. Woldegebriel, A.N.V. Stewart, and R. Savage, *Lincoln University*.

The primary objective of this experiment was to determine how long sperm motility could be maintained at 39° C in extenders/media designed for room temperature storage. Spermatozoa were also evaluated with Hoescht and chlortetracycline (CTC) to determine % alive and capacitation status, respectively. Semen was collected from 2 to 4 rams, pooled, and diluted to 50 x 10<sup>6</sup> sperm/ml in the appropriate extender. Extenders used were ram semen diluter (RSD-1), caprogen and synthetic oviductal fluid (SOF). Within 30 minutes of extension, 39° C incubation

was initiated. One-half of the samples were incubated in 5 % CO<sub>2</sub>/95 % air, and the remaining half were incubated in 100 % N<sub>2</sub> gas. Motility, live-dead, capacitation and acrosomal status were evaluated at 0, 4, 24, 48 and 72 h of incubation. Osmolarity was 295, 353 and 280 mOsm for RSD-1, caprogen and SOF, respectively. There was no difference between N<sub>2</sub> gas and 5 % CO<sub>2</sub>/95 % air on motility scores when incubated in caprogen or SOF. Motility scores in RSD-1 were not different at 4, 24 or 72 h of incubation. Motility was greater ( $P \leq .05$ ) at 48 h when RSD-1 cultured sperm were incubated in CO<sub>2</sub> and air ( $1.1 \pm .2$ ) than in N<sub>2</sub> gas ( $.6 \pm .2$ ). RSD-1 maintained motility for 24 h (motility score  $2.5 \pm .4$ ) which was better ( $P \leq .01$ ) than both caprogen (motility score  $.1 \pm .1$ ) and SOF (motility score  $.7 \pm .1$ ). There was no motility at 48 and 72 h of culture when sperm were incubated in caprogen or SOF, and only minimal motility when incubated in RSD-1 ( $.9 \pm .2$  and  $.2 \pm .1$ , respectively). Live/dead staining followed the same trend except that over 10 % were classified as live in all treatments at 72 h of incubation. Neither incubation time, type of media, nor gas used for incubation caused sperm to be classified as capacitated or acrosome reacted. In conclusion, RSD-1 was the best extender tested for body temperature storage of ram sperm, although significant motility was maintained for only 48 h.

**Key Words:** Semen Extenders, Sperm Motility, Body Temperature

**224 Effects of zeranol upon luteal maintenance and fetal development in peripubertal gilts.** W.E. Trout<sup>1</sup>, C.T. Herr<sup>2</sup>, B.T. Richert<sup>2</sup>, W.L. Singleton<sup>2</sup>, and M.A. Diekmann<sup>2</sup>, <sup>1</sup> *Trout Technologies*, <sup>2</sup> *Purdue University*.

The objectives of this study were to determine whether zeranol could maintain hCG-induced corpora lutea (CL) in peripubertal gilts and to examine the gross effects of zeranol on the number of fetuses and their development. Crossbred gilts ( $171 \pm 0.3$  d of age,  $109.1 \pm 1.4$  kg) were blocked by weight and ancestry to control ( $n=40$ ) or treatment ( $n=40$ ) groups. To induce ovulation and CL formation, treated gilts received 500 IU of hCG and a Ralgro<sup>®</sup> ear implant (zeranol, 36 mg; d 0). On d 42, treated gilts received two 10 mg injections of Lutalyse (PG) spaced 6 h apart. Treated gilts not displaying estrus within 7 d of PG treatment on d 42 received an additional 20 mg of PG on d 49. All gilts were checked once daily for estrus with a mature boar starting on d 3. On d 45-58, gilts detected in estrus were inseminated twice 24 hours apart with pooled semen via AI. Blood samples were obtained on d 0, 7, 18 and 42 and analyzed for serum progesterone (P4). Bred gilts were slaughtered on d 58-62 of gestation. Zeranol appeared to maintain hCG-induced CL function based on 45% of treated gilts vs 0% of control gilts having elevated P4 on d 7, 18 and 42 ( $P < .0001$ ). Of gilts detected in estrus and bred on d 45-58, 16/21 treated gilts and 16/18 control gilts were pregnant at slaughter on d 58-62 of gestation. Number of fetuses (7.5 vs 12), fetal weight, (83 vs 121 g), fetal length (117 vs 132 mm) and fetal survival (45% vs 78%) were reduced ( $P < .001$ ) by zeranol. These data indicate that treatment of peripubertal gilts with a 36 mg zeranol implant did maintain pseudopregnancy, but did not significantly improve estrous synchronization while causing dramatic deleterious effects upon the fetuses.

**Key Words:** Ralgro, Pseudopregnancy, Swine

**225 Feeding melengestrol acetate (MGA) to resynchronize repeat estrus in beef heifers previously synchronized using a MGA/Prostaglandin F<sub>2α</sub> protocol.** C. R. Dahlen\* and G. C. Lamb, *University of Minnesota*.

One hundred twenty-one commercial beef heifers were used to determine whether feeding melengestrol acetate (MGA) for 7 d, after an initial estrous synchronization with an MGA/Prostaglandin F<sub>2α</sub> (PGF) protocol,

would resynchronize repeat estrus in heifers that either had an embryo transferred or were previously observed in estrus, and initiate cycling in heifers that were not previously observed in estrus. Initial estrous synchronization was achieved by feeding 0.5 mg MGA daily for 13 d, followed 19 d later with one 25-mg injection of PGF. Seventy-four heifers received embryos 7 d after observed estrus. Heifers were randomly assigned to one of two treatments: 1) heifers were fed 0.5 mg MGA daily for 7 d, beginning 15 d after PGF (Resynch;  $n = 61$ ); or 2) heifers did not receive MGA from d 15 to d 21 after PGF (Control;  $n = 60$ ). If observed in estrus (observed visually 4x daily, from d 10 to d 31 after PGF), heifers were inseminated following the am/pm rule. On d 35 and d 71 after PGF, transrectal ultrasonography was used to determine the presence of a viable fetus. Of the 34 Resynch heifers receiving an embryo, 23 were pregnant, whereas 22 of the 41 Control heifers receiving an embryo were pregnant. The percentage of heifers detected in estrus from d 23 to d 31 was greater ( $P < .01$ ) for Resynch heifers (28/30 [74%]) than Control heifers (16/38 [42%]). Estrus was induced (i.e., a heifer in estrus that had not previously been observed in estrus) in 11 of 15 Resynch heifers and 7 of 12 Control heifers (73% vs. 58%, respectively). Conception rates were similar for Resynch (15/28 [54%]) and Control (10/16 [63%]) heifers. Overall pregnancy rates after 2 estrous synchronizations were 62% (38/61) for Resynch heifers and 53% (32/60) for Control heifers. We conclude that feeding MGA to resynchronize repeat estrus in commercial beef heifers may increase the percentage of animals observed in estrus, without altering pregnancy rates.

**Key Words:** Estrous Synchronization, Beef Heifers

**226 Response of the small intestine to pregnancy in Romanov and Columbia ewes.** A.N. Scheaffer, J.S. Luther\*, D.R. Arnold, M.L. Bauer, D.A. Redmer, J.S. Caton, and L.P. Reynolds, *North Dakota State University*.

Pregnancy results in a large increase (50% by the end of gestation) in energy demands. To evaluate small intestinal responses to the metabolic demand of pregnancy, litter-bearing (R,  $n = 4$ ) and standard (C,  $n = 3$ ) ewes, which were mated to rams of their respective breeds, were slaughtered on day 130 of gestation. Weights of the gravid uterus, fetuses, total small intestine, and jejunum were determined. In addition, a sample of jejunum was perfusion-fixed, embedded in paraffin, and sectioned. Jejunal tissue sections were used to quantify vascularity (vascular density = percentage of tissue occupied by capillaries, arterioles, and venules) using morphometric techniques. Compared with C ewes, R ewes had a smaller ( $P < 0.01$ ) live weight (LW;  $98.1$  vs  $44.8 \pm 7.9$  kg) and maternal body weight (MBW [LW - (blood+gut fill+gravid uterus)];  $68.2$  vs  $24.5 \pm 7.8$  kg). Compared with C ewes, R ewes also had smaller ( $P < 0.01$ ) individual fetal ( $4.7$  vs  $2.2 \pm 0.3$  kg) but similar ( $P = 0.41$ ) total fetal ( $6.6$  vs  $4.5 \pm 0.32$  kg) weights. However, when scaled to maternal body weight, R ewes had greater ( $P < 0.01$ ) gravid uterine weights than C ewes ( $282$  vs  $163 \pm 30$  g/kg MBW). R ewes also had greater ( $P < 0.01$ ) total small intestinal and jejunal weights ( $37.1$  vs  $17.3 \pm 2/5$  g/kg MBW and  $24.2$  vs  $9.9 \pm 2/1$  g/kg MBW, respectively). In addition, jejunal vascularity was greater ( $P < 0.05$ ) in R compared with C ewes ( $20.2$  vs  $12.1 \pm 2.7\%$ ). These data demonstrate that, compared with Columbia ewes, Romanov ewes support a 40% greater gravid uterine mass per unit of maternal body weight. The intestinal response to this greater metabolic demand of pregnancy in Romanov ewes is reflected by a 2-fold larger, 70% more vascular small intestine. Supported by NIH grant HL64141 to DAR and LPR.

**Key Words:** Pregnancy, Small Intestine, Vascularity

## Ruminant Nutrition And Forages

**227 Changes in nutritive value of tall fescue hay as affected by natural rainfall and initial moisture concentration at baling.** J. E. Turner, W. K. Coblenz, D. A. Scarbrough, R. T. Rhein\*, K. P. Coffey, D. W. Kellogg, C. F. Rosenkrans, Jr., and J. V. Skinner, Jr., *University of Arkansas*.

Relatively little is known about the combined effects of rain damage and spontaneous heating on the storage characteristics and nutritive value

of tall fescue (*Festuca arundinacea*, Schreb.) hay. Our objectives were to assess the effects of these variables for tall fescue hay in five different management situations. Kentucky 31 tall fescue infected with the fungal endophyte (*Neotyphodium coenophialum*) was packaged in conventional rectangular bales at 99 (low), 164 (ideal), and 225 (high) g kg<sup>-1</sup> of moisture (L, I, and H respectively) prior to rainfall and at 246 g kg<sup>-1</sup> of moisture after a 2.26 cm rainfall event (H-R) and at

was initiated. One-half of the samples were incubated in 5 % CO<sub>2</sub>/95 % air, and the remaining half were incubated in 100 % N<sub>2</sub> gas. Motility, live-dead, capacitation and acrosomal status were evaluated at 0, 4, 24, 48 and 72 h of incubation. Osmolarity was 295, 353 and 280 mOsm for RSD-1, caprogen and SOF, respectively. There was no difference between N<sub>2</sub> gas and 5 % CO<sub>2</sub>/95 % air on motility scores when incubated in caprogen or SOF. Motility scores in RSD-1 were not different at 4, 24 or 72 h of incubation. Motility was greater ( $P \leq .05$ ) at 48 h when RSD-1 cultured sperm were incubated in CO<sub>2</sub> and air ( $1.1 \pm .2$ ) than in N<sub>2</sub> gas ( $.6 \pm .2$ ). RSD-1 maintained motility for 24 h (motility score  $2.5 \pm .4$ ) which was better ( $P \leq .01$ ) than both caprogen (motility score  $.1 \pm .1$ ) and SOF (motility score  $.7 \pm .1$ ). There was no motility at 48 and 72 h of culture when sperm were incubated in caprogen or SOF, and only minimal motility when incubated in RSD-1 ( $.9 \pm .2$  and  $.2 \pm .1$ , respectively). Live/dead staining followed the same trend except that over 10 % were classified as live in all treatments at 72 h of incubation. Neither incubation time, type of media, nor gas used for incubation caused sperm to be classified as capacitated or acrosome reacted. In conclusion, RSD-1 was the best extender tested for body temperature storage of ram sperm, although significant motility was maintained for only 48 h.

**Key Words:** Semen Extenders, Sperm Motility, Body Temperature

**224 Effects of zeranol upon luteal maintenance and fetal development in peripubertal gilts.** W.E. Trout<sup>1</sup>, C.T. Herr<sup>2</sup>, B.T. Richert<sup>2</sup>, W.L. Singleton<sup>2</sup>, and M.A. Diekmann<sup>2</sup>, <sup>1</sup> *Trout Technologies*, <sup>2</sup> *Purdue University*.

The objectives of this study were to determine whether zeranol could maintain hCG-induced corpora lutea (CL) in peripubertal gilts and to examine the gross effects of zeranol on the number of fetuses and their development. Crossbred gilts ( $171 \pm 0.3$  d of age,  $109.1 \pm 1.4$  kg) were blocked by weight and ancestry to control (n=40) or treatment (n=40) groups. To induce ovulation and CL formation, treated gilts received 500 IU of hCG and a Ralgro<sup>®</sup> ear implant (zeranol, 36 mg; d 0). On d 42, treated gilts received two 10 mg injections of Lutalyse (PG) spaced 6 h apart. Treated gilts not displaying estrus within 7 d of PG treatment on d 42 received an additional 20 mg of PG on d 49. All gilts were checked once daily for estrus with a mature boar starting on d 3. On d 45-58, gilts detected in estrus were inseminated twice 24 hours apart with pooled semen via AI. Blood samples were obtained on d 0, 7, 18 and 42 and analyzed for serum progesterone (P4). Bred gilts were slaughtered on d 58-62 of gestation. Zeranol appeared to maintain hCG-induced CL function based on 45% of treated gilts vs 0% of control gilts having elevated P4 on d 7, 18 and 42 ( $P < .0001$ ). Of gilts detected in estrus and bred on d 45-58, 16/21 treated gilts and 16/18 control gilts were pregnant at slaughter on d 58-62 of gestation. Number of fetuses (7.5 vs 12), fetal weight, (83 vs 121 g), fetal length (117 vs 132 mm) and fetal survival (45% vs 78%) were reduced ( $P < .001$ ) by zeranol. These data indicate that treatment of peripubertal gilts with a 36 mg zeranol implant did maintain pseudopregnancy, but did not significantly improve estrous synchronization while causing dramatic deleterious effects upon the fetuses.

**Key Words:** Ralgro, Pseudopregnancy, Swine

**225 Feeding melengestrol acetate (MGA) to resynchronize repeat estrus in beef heifers previously synchronized using a MGA/Prostaglandin F<sub>2α</sub> protocol.** C. R. Dahlen\* and G. C. Lamb, *University of Minnesota*.

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## Ruminant Nutrition And Forages

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Relatively little is known about the combined effects of rain damage and spontaneous heating on the storage characteristics and nutritive value

of tall fescue (*Festuca arundinacea*, Schreb.) hay. Our objectives were to assess the effects of these variables for tall fescue hay in five different management situations. Kentucky 31 tall fescue infected with the fungal endophyte (*Neotyphodium coenophialum*) was packaged in conventional rectangular bales at 99 (low), 164 (ideal), and 225 (high) g kg<sup>-1</sup> of moisture (L, I, and H respectively) prior to rainfall and at 246 g kg<sup>-1</sup> of moisture after a 2.26 cm rainfall event (H-R) and at

93 g kg<sup>-1</sup> of moisture after a total accumulation of 7.07 cm of rain (L-R). Heating degree-days > 30 (JavaScript:degree()C (HDD) accumulated were greater (P JavaScript:leq() 0.05) for the H (163) than the H-R (129) hay; the other baling treatments accumulated minimal HDD. Concentrations of fiber components immediately after baling were increased substantially (P < 0.05) by rain damage but concentrations of N and N-associated-fiber components were only marginally affected by rain damage. Concentrations of most fiber and fiber-associated N increased (P < 0.05) during a 40-d storage period but were fairly limited during the storage period, due to the low concentrations of moisture at baling and the limited HDD accumulated. In situ DM disappearance after 48 h (ISDMD) was lower (P < 0.05) at baling for the L-R hay than hays packaged without rainfall, while ISDMD was similar (P > 0.05) for the H, H-R, and L-R hays after the storage period. Hay that was exposed to rainfall generally had greater concentrations of fiber components and ADIN at the end of the storage period than hay that was not exposed to rainfall. Rainfall after mowing decreased the nutritive value and ISDMD of these hays. Generally, hays packaged at less than 200 g kg<sup>-1</sup> were not affected adversely by storage, while those packaged above this concentration of moisture produced poorer quality hays.

**Key Words:** Rain Damaged Hay, Tall Fescue

**228 Effect of legume persistence in endophyte-infected tall fescue pastures on forage production and steer performance.** L.W. Lomas\*, J.L. Moyer, and G.L. Kilgore, *Kansas State University, Parsons.*

Grazing and subsequent finishing performance of steers that grazed high-endophyte tall fescue pastures previously interseeded with lespedeza, ladino clover, or red clover in 1995, 1996, and 1997 were evaluated. Initial weights of steers grazed in 1998, 1999, and 2000 were 260.3, 256.8, and 250.4 kg, respectively. Nine 2.02-ha established #Kentucky 31' tall fescue pastures with more than 65% endophyte infection were used in a randomized complete block design with three replications per legume treatment. Five mixed-breed steers were randomly allotted to each pasture on April 1, 1998, March 30, 1999, and April 4, 2000 and grazed continuously for 223, 218, and 218 d, respectively, and then transported to a feedlot facility and fed a finishing diet for 154, 140, and 111 d, respectively. All steers were fed .9 kg of ground grain sorghum per head daily during the grazing phase. Legume cover, available forage DM, grazing steer performance, subsequent feedlot performance, and carcass parameters were measured. Available forage DM was higher (P < .01) in pastures with ladino clover than in those with lespedeza in all 3 yr, and higher (P < .05) than those with red clover in 1999 and 2000. Legume coverage was highest (P < .01) for pastures with ladino clover and similar (P > .05) for pastures with red clover and lespedeza in all 3 yr. However, ladino clover coverage declined from 10.5% in 1998 to 1.3% in 2000. Gains by steers grazing lespedeza, ladino clover, and red clover treatments were .42, .56, and .47 kg/d in 1998; .44, .45, and .46 kg/d in 1999; and .46, .48, and .51 kg/d in 2000. In 1998, steers grazing ladino clover pastures gained 33.5% more (P < .01) and 20.2% more (P < .05), respectively, than those grazing lespedeza and red clover pastures. Gains by steers grazing red clover and lespedeza pastures were not different (P > .05). Grazing gains between legume treatments were not different (P > .05) during 1999 and 2000. Legume treatment during the grazing phase had no effect (P > .05) on finishing performance or carcass parameters except steers that grazed pastures interseeded with red clover in 1998 gained more (P < .05) than those that grazed pastures interseeded with ladino clover. Overall gains from the beginning of the grazing phase through the end of the finishing phase were similar between legume treatments.

**Key Words:** Tall Fescue, Legumes, Grazing

**229 Performance of lambs grazing three different forages during the summer months in Missouri.** D.O. Kiesling\*, A.N.V. Stewart, A. Woldegebriel, S. Meredith, G. Dudenhofer, and R. Savage, *Lincoln University, Jefferson City, MO/USA.*

The objective of this experiment was to evaluate growth rate and carcass characteristics of lambs grazing different warm-season forages. Forty-eight lambs (40 ± 2 kg) were divided into three groups and randomly assigned to the following grazing paddocks: 1) forage soybean (*Glycine max*; n = 12); 2) foxtail millet (*Setaria italica*; n = 18); and 3) sorghum sudan bmr (*Sorghum bicolor*; n = 18). Lambs received a 14% CP grain

ration (227 g·hd<sup>-1</sup>·d<sup>-1</sup>) along with alfalfa hay (227 g·hd<sup>-1</sup>·d<sup>-1</sup>) during the grazing trial. The number of lambs in each paddock was determined by the size of the pasture. The grazing trial was initiated in mid July and completed at the end of August (42 d). Lambs were weighed every 2 wks during the grazing trial. At the end of the grazing trial, ultrasound was performed to measure loin eye area and backfat thickness. Four wethers from each paddock were placed in drylot and fed a 14% CP ration at 908 g·hd<sup>-1</sup>·d<sup>-1</sup> and fed hay ad libitum for 2 wks before evaluation of carcass characteristics. Total gain of lambs during the grazing trial was higher (P < 0.05) for paddock 1 (5.87 ± 0.89 kg) than for paddock 2 (1.84 ± 0.76 kg) or paddock 3 (2.5 ± 0.68 kg). Backfat thickness of lambs in paddocks 1 and 3 (0.09 ± 0.006 in) was higher (P < 0.05) than in paddock 2 (0.07 ± 0.006 in). There was no difference in loin eye area among lambs grazing the different forages. Also carcass characteristics of wethers placed in drylot were not different. In conclusion, all three forages proved satisfactory for summer grazing, however, lambs grazed on forage soybean gained better than lambs on the other two forages.

**Key Words:** Lambs, Forages, Carcass characteristics

**230 Improving utilization of soybean hulls by cattle with digestive enzymes and dietary buffers.** C. A. Loest\*, E. C. Titgemeyer, J. S. Drouillard, B. J. Johnson, A. M. Trater, and B. D. Lambert, *Kansas State University, Manhattan.*

Four ruminally cannulated Holstein steers (340 kg) were used in a 4 × 4 Latin square to evaluate the benefits of supplementing digestive enzymes and dietary buffers to a soybean hull-based diet (95.5% soyhulls, 3% molasses, 1% minerals, 0.5% urea) fed once daily at 7.0 kg/d (as fed basis). Treatments were mixed with the diet and included: 1) control (C), 2) 3 g/d digestive enzymes (E), 3) 62 g/d NaHCO<sub>3</sub> and 31 g/d MgO (B), and 4) E plus B (EB). Enzymes were from *Trichoderma reesei* and included activities of β-glucanase, galactomannanase, xylanase, and mannanase. Periods were 14 d with 8 d for adaptation, 5 d for fecal collections, and 1 d for rumen fluid collections. Digestibilities of OM (75.9, 76.2, 76.5, and 78.6% for C, E, B, and EB) and NDF (77.2, 77.6, 77.7, and 79.9% for C, E, B, and EB) increased (P ≤ 0.05) with enzyme or buffer supplementation. Digestibilities of ADF (74.7, 74.9, 75.4, and 77.8% for C, E, B, and EB) also increased (P ≤ 0.05) with buffer addition and tended to increase (P = 0.06) with enzyme addition. Enzyme and buffer addition did not alter passage of liquid (4.8, 5.1, 4.9, and 4.7%/h for C, E, B, and EB) or solids (3.4, 3.7, 4.0, and 3.5%/h for C, E, B, and EB) and therefore cannot account for any of the responses in digestion. Rumenal pH (5.88, 5.97, 5.90, and 5.99 for C, E, B, and EB) and of NH<sub>3</sub> (9.9, 10.0, 10.0, and 8.5 mM for C, E, B, and EB) and total VFA (134, 127, 148, and 131 mM for C, E, B, and EB) were not altered by enzyme or buffer supplementation. However, enzyme addition resulted in lower (P ≤ 0.05) molar proportions of propionate and tended to increase (P = 0.10) proportions of butyrate. Enzyme addition also resulted in greater molar proportions of branched-chain VFA (isobutyrate, P ≤ 0.05; isovalerate, P = 0.08). Results demonstrated that both digestive enzyme and buffer supplementation improved the digestibility of soybean hull-based diet, and responses were greatest when both additives were supplemented together.

**Key Words:** Soybean Hulls, Enzyme, Buffer, Cattle

**231 Effect of processing sprouted grains on performance and carcass characteristics of beef steers.** J.J. Reed\*, E.R. Loe, M.L. Bauer, and G.P. Lardy, *North Dakota State University.*

The feeding value of sprouted barley and sprouted durum in finishing rations was evaluated using 141 crossbred steers (417.4 ± 5.4 kg initial BW) fed for 83 d or 108 d. Steers were blocked by weight and allotted randomly to five treatments in 25 pens. Treatments were dry-rolled corn (CON), whole sprouted barley (WB), rolled sprouted barley (RB), whole sprouted durum (WD), and coarse-rolled sprouted durum (RD). Diets contained 77% grain, 8.5% wet beet pulp, 5% CSB, 4.0% alfalfa, and 5.5% supplement containing 30 mg/kg monensin and 11 mg/kg tylosin. The durum diets contained 37% corn and 40% durum as the grain source. Diets were formulated to contain a minimum 13.5% CP, 0.7% Ca, 0.28% P, and 0.94% K. Data were analyzed as a 2 × 2 plus 1 factorial arrangement of treatments. Particle size was 3438 and 2897 μm for WB and RB and 2628 and 2287 μm for WD and RD. There was a grain × processing interaction (P = .01) for DMI; steers fed RB ate more than WB while steers fed RD ate less than WD. Corn-fed steers ate less (P =

0.02) than barley-fed steers. Steers fed rolled grains were heavier, had increased ADG, and were more efficient ( $P < 0.001$ ). Steers fed durum were heavier, gained faster, ate less, were more efficient, and were fatter ( $P > 0.05$ ) compared to barley-fed steers. Corn-fed steers were similar to durum-fed but were heavier, gained faster, ate less, were more efficient, and had increased marbling ( $P < 0.05$ ) compared to barley-fed steers. Feeding corn improves performance and carcass quality of steers compared to barley. Rolling sprouted grains increases performance of steers fed finishing rations.

Item	CON	WB	RB	WD	RD	SEM
ADG, kg	1.78	1.29	1.52	1.54	1.68	0.09
DMI, kg/d	11.23	11.75	11.95	11.61	10.90	0.35
G:F	0.159	0.101	0.127	0.133	0.155	0.002
HCW, kg	369.8	340.5	359.4	355.8	370.2	6.1
Fat, cm	0.86	0.71	0.76	0.84	0.84	0.02
Marbling	419	371	385	388	394	11

**Key Words:** Grain, Processing, Steers

**232 Characterizing the ensiling properties of wet beet pulp. I. Addition of dry feedstuffs.** A.M. Encinias\*, T.C. Gilbery, G.P. Lardy, M.L. Bauer, and J.S. Caton, *North Dakota State University*.

Ensiling properties of wet sugar beet pulp (WBP; 25% DM) mixed with dry feedstuffs (>85% DM) was evaluated in a 47 d study. Treatments were arranged in a 4#6#2 factorial (3 replicates) to determine the effects of: 1) DM, 2) feedstuff, and 3) addition of beet tailings on ensiling characteristics of WBP. Levels of DM tested were 25, 30, 35, 40, 45, and 50%. Feedstuffs added to WBP included: dry pelleted beet pulp (DPB), dry pelleted corn gluten feed (DCGF), dry rolled corn (DRC), or wheat midds (WM). The third component was addition of sugar beet tailings (WBT) to make up 25% DM of the ensiled product . Replicates were individually sealed into 2 heavy-duty plastic liners within a 19-L bucket and fermented for 47 d. Following fermentation, pH was measured and samples were analyzed for CP, soluble CP, IVDMD, VFA, and lactic acid. Dry feedstuffs, with exception of DRC, increased ( $P < 0.001$ ) pH of ensiled WBP. Inclusion of DCGF, DRC, and WM enhanced ( $P < 0.001$ ) protein fractions (crude and soluble), whereas DBP decreased CP and soluble CP ( $P < 0.001$ ). Pelleted DBP, DCGF, and DRC, but not WM, improved ( $P < 0.05$ ) IVDMD. Lactic acid ( $P = 0.11$ ), total VFA ( $P < 0.001$ ), and total organic acids ( $P < 0.001$ ) decreased with DBP addition. Lactic acid production increased ( $P < 0.05$ ) in ensiled WBP products containing DCGF (up to 30% DM), DRC (up to 35% DM) and WM. Total VFAs decreased ( $P < 0.05$ ) with inclusion of DCGF and WM, and increased ( $P < 0.001$ ) with DRC (up to 40% DM). Moreover, total organic acids were suppressed ( $P < 0.05$ ) in DCGF and enhanced ( $P < 0.001$ ) in DRC and WM. Addition of WBT did not influence ( $P < 0.05$ ) CP, soluble CP, or IVDMD of ensiled WBP products with dry feedstuffs. Lactic acid was not affected ( $P < 0.05$ ) with addition of WBT. However, added WBT increased ( $P < 0.05$ ) total VFA in DCGF and WM, but not DBP or DRC. Nutrient quality of ensiled WBP was influenced by inclusion of dry feedstuff. Additionally, WBT (included at 25% DM ) improved fermentation characteristics of some WBP-dry feedstuff combinations.

**Key Words:** Silage, Wet Beet Pulp, Feedstuffs

**233 Inclusion of sprouted grain in steer grower diets and effect on performance.** J.J. Reed\*, E.R. Loe, M.L. Bauer, G.P. Lardy, and J.S. Caton, *North Dakota State University*.

The feeding value of sprouted barley and sprouted durum in grower rations was evaluated using 142 crossbred steers (328.1 ± 1.7 kg initial BW) fed for 62 d. Steers were blocked by weight and allotted randomly to dietary treatments (5 pens/treatment). Treatments were dry-rolled corn (CON), coarse-rolled sprouted barley (CRB), fine-rolled sprouted barley (FRB), whole sprouted durum (WD), and coarse-rolled sprouted durum (CRD). Diets contained 40% grain, 35% corn silage, 20% alfalfa, and 5% supplement containing 28 mg/kg monensin. All diets were formulated to contain a minimum 12% CP, 0.60% Ca, 0.27% P, and 0.93% K. Initial weight and final weight were an average of two consecutive day weights. Grain samples were taken weekly and composited for analysis of particle size. Data was analyzed as a 2 x 2 plus 1 factorial arrangement of treatments with GLM procedure of SAS. There were no grain

x processing interactions ( $P > 0.28$ ). Particle size was 2722 ± 1.45 and 1998 ± 1.74 µm for coarse-rolled and fine-rolled barley. Particle size was 2628 ± 1.24 and 2126 ± 1.52 µm for whole durum and rolled durum. Fine rolling barley increased final weight, ADG, and feed efficiency ( $P < 0.07$ ). Rolling durum increased final weight, ADG, and feed efficiency ( $P < 0.01$ ). There were no differences in corn versus barley or corn versus durum ( $P > 0.25$ ). Treatment did not have an effect on DMI ( $P > 0.13$ ). Fine rolling sprouted barley and rolling sprouted durum increased performance of steers fed silage-based grower rations.

Item	CON	CRB	FRB	WD	CRD	SEM
Final wt, kg	413.2	416.7	422.9	415.4	423.5	5.4
ADG, kg	1.34	1.40	1.51	1.40	1.51	0.09
DMI, kg/d	9.50	9.43	9.50	9.74	9.47	0.26
G:F	0.141	0.149	0.159	0.144	0.160	0.004

**Key Words:** Grain, Processing, Steers

**234 Characterizing the ensiling properties of wet beet pulp. II. Addition of liquid feedstuffs.** A.M. Encinias\*, T.C. Gilbery, G.P. Lardy, M.L. Bauer, and J.S. Caton, *North Dakota State University*.

Objectives of this project were to determine ensiling properties for wet sugar beet pulp (WBP) ensiled with combinations of liquid feedstuffs. Effects evaluated included: 1) type of liquid feedstuff and 2) level of liquid byproduct feedstuff on a WBP based ensiled product arranged in a 3 x 4 factorial experimental design. Ensiled products were mixed to achieve four DM levels: 25, 30, 35, or 40%. Liquid feedstuffs used were beet molasses (MOL), concentrated separator byproduct (CSB), and corn steep liquor (CSL). Silage products were prepared in triplicate and sealed into 2 heavy-duty plastic liners within a 19 L bucket and fermented for 47 d. Following fermentation, pH was measured and samples were analyzed for DM, CP, soluble CP, IVDMD, VFA, and lactate. Inclusion of MOL and CSB increased ( $P < 0.002$ ) pH of ensiled WBP, whereas pH was not affected ( $P = 0.63$ ) with CSL. Maximum CP of ensiled WBP (8.55%) was observed at 35, 40, and 40 % DM in MOL (mean = 10.68), CSB(mean = 19.37) and CSL (mean = 22.56), respectively. Soluble CP were highest at 40% DM in all treatments. Increasing DM to 40% improved ( $P < 0.001$ ) IVDMD in all treatments. Molasses, CSB, and CSL, when added to WBP, increased ( $P < 0.001$ ) lactic acid production. Total VFA (% DM) in ensiled WBP products numerically peaked in MOL (8.10), CSB (10.42), and CSL (6.42) at 30% DM. Ratio of acetate to total VFA increased ( $P < 0.001$ ) in MOL (up to 40% DM), CSB (up to 35% DM), and decreased with inclusion of CSL ( $P = 0.001$ ). Inclusion of MOL, CSB, or CSL increased total organic acid content, and were highest at 40, 35, and 30% DM, respectively. Results of the current study indicate that ensiling WBP (25% DM) with MOL, CSB, or CSL up to 40% DM improved protein and digestibility fractions. Moreover, lactic acid concentration increased, however total VFA and organic acid was more variable as DM increased in ensiled WBP products. In conclusion, the most desirable fermentation environment may be achieved above 35% DM when ensiling WBP with MOL, CSB, or CSL.

**Key Words:** Silage, Wet Beet Pulp , Concentrated Separator Byproduct

**235 Effect of field pea level on intake, digestion, and ruminal fermentation in beef steers fed growing diets.** J.J. Reed\*, G.P. Lardy, T.C. Gilbery, M.L. Bauer, and J.S. Caton, *North Dakota State University*.

Four ruminally and duodenally cannulated steers (367 ± 48 kg initial BW) were used in 4 x 4 Latin square to evaluate the effect of field pea inclusion level on intake, site and rate of digestion, ruminal fermentation, and ruminal fill in steers fed growing diets. The control diet consisted of 50% corn, 25% corn silage, 20% alfalfa hay, and 5% supplement (DM basis). Field pea replaced corn at 0, 33, 67, and 100%, forming the treatments. Diets were formulated to contain at least 12% CP, 0.62% Ca, 0.3% P, and 0.8% K. Steers were adapted to diets for 9 d. On d 10 to 14, intakes were measured. Field pea was incubated in situ, beginning on d 10, for 0, 2, 4, 8, 12, 16, 24, 36, 48, 72, and 96 h. Ruminal fluid was collected and pH recorded at -2, 0, 2, 4, 6, 8, 10, and 12 h post-feeding on d 13. Duodenal samples were taken for three consecutive days beginning on d 10 in a manner that allowed for a collection to take place every other hour for a 24 h period. Dry matter intake (13.8, 11.4,



13.6,  $11.1 \pm 1.4$  kg) decreased ( $P < 0.09$ ) in a linear and cubic manner with increasing field pea. In situ DM disappearance of field pea (2.2, 3.9, 1.6,  $2.8 \pm 0.5$  %/h) changed ( $P < 0.02$ ) cubically with increasing levels of field pea. Increasing field pea tended to linearly increase ( $P < 0.08$ ) total tract DM (68.6, 75.9, 76.1,  $75.5 \pm 2.0$ %), OM (88.1, 90.9, 90.9,  $90.6 \pm 0.8$ %), and NDF (84.1, 89.0, 89.0,  $88.7 \pm 1.0$ %) digestion. There were no effects observed ( $P > 0.3$ ) in total tract CP ( $79.7 \pm 1.9$ %) or apparent ruminal DM ( $74.8 \pm 1.1$ %) digestion. Increasing field pea linearly decreased ( $P < 0.03$ ) ruminal fill (7.4, 6.0, 5.1,  $5.3 \pm 0.9$  kg), ruminal pH (6.7, 6.7, 6.4,  $6.6 \pm 0.03$ ), and fecal output (4.0, 3.0, 3.0,  $3.0 \pm 0.5$  kg). It appears field pea is a suitable substitute for corn in growing diets.

**Key Words:** Cattle, Field Pea, Digestibility

**236 Characterizing the ensiling properties of wet beet pulp. III. Addition of urea.** A.M. Encinas\*, T.C. Gilbery, G.P. Lardy, M.L. Bauer, and J.S. Caton, *North Dakota State University*.

An experiment was designed to evaluate the addition of urea as a method to enhance utilization of ensiled WBP. Two ensiled WBP products were evaluated: 1)WBP (without urea), or 2)WBP (with urea). Urea was added (6.4 g /kg DM) to WBP in +urea treatment and thoroughly mixed. Silage products were prepared in triplicate and sealed in 2 heavy-duty plastic liners within a 19-L bucket and fermented for 47 d. Following fermentation, pH was measured and samples were analyzed for DM, CP, soluble CP, IVDMD, VFA, and lactate. In the current experiment there was no effect ( $P = 0.45$ ) of added urea on pH (4.13 vs 4.11 0.06). Feed DM was increased ( $P = 0.03$ ; 31.8 vs 27.9 0.8%) with urea addition. Ensiled products which included urea had higher CP ( $P < 0.0001$ ; 12.12 vs 9.50 0.06%) and soluble CP ( $P < 0.0001$ ; 6.19 vs 3.63 0.06%) than without urea. Added urea however, did not influence IVDMD ( $P = 0.15$ ; 83.6 vs 82.6 0.4%) in the current experiment. Lactate (% DM) increased with the addition of urea ( $P = 0.02$ ; 5.21 vs 4.20 0.20). Moreover, VFA's increased ( $P = 0.03$ ) 22% in ensiled WBP products with urea. Acetate (% of total VFA) increased 3% with added urea ( $P = 0.006$ ). Furthermore, enhanced lactic acid and VFA resulted in increased ( $P = 0.002$ ) total organic acid (10.71 vs 8.71 0.32%) of ensiled WBP products with urea vs without urea, respectively. The results of the current experiment indicate WBP may be ensiled with urea to increase DM content, promote a more desirable fermentation environment, and increase nutrient quality after a 47 d fermentation period.

**Key Words:** Silage, Wet Beet Pulp, Urea

**237 Influence of advancing season on intake, site of digestion, and microbial efficiency in beef steers grazing native range in western North Dakota.** H. J. Pitcher\*<sup>1</sup>, J. S. Caton<sup>1</sup>, D. A. Cline<sup>1</sup>, M. L. Bauer<sup>1</sup>, L. L. Manske<sup>2</sup>, and G. P. Lardy<sup>1</sup>, <sup>1</sup>*North Dakota State University, Fargo*, <sup>2</sup>*North Dakota State University, Dickinson*.

Effects of advancing season on intake, site and extent of digestion, and microbial efficiency in steers grazing native mixed-grass prairie in western North Dakota were evaluated in five sampling periods. Four cross-bred steers ( $349.9 \pm 17.4$  kg initial wt), fitted with ruminal and duodenal cannula, grazed a 4.5 month season-long pasture. Sampling periods (10 d) were early June, late July to early August, late August, mid-September, and mid-November. Chromic oxide (8 g twice daily) was dosed on d 1 to 10. Masticate samples were taken on d 1 prior to marker dosing. Duodenal and fecal samples were taken at 0, 4, 8, and 12 h on d 6 to 10. Dietary N content (% OM) decreased linearly across season ( $P < 0.01$ ; 1.95, 1.41, 1.56, 1.24,  $1.15 \pm 0.11$ ). In addition, OM intake (g/kg BW) decreased linearly across season ( $P = 0.001$ ); highest in late June (31.7) and lowest in mid-November (13.4). Total tract and true ruminal OM digestion decreased linearly across season ( $P < 0.001$ ). Organic matter digestion in the small intestine did not change as a percent of intake; however, OM digestion as a percent of entering decreased ( $P = 0.002$ ) with advancing season. Ruminal N digestion decreased linearly with advancing season ( $P < 0.04$ ); however, small intestinal N digestion increased across season ( $P < 0.08$ ). A greater portion of N was apparently digested in the small intestine than ruminally. Apparent ruminal N digestion was negative at all periods with the exception of late June indicating substantial N recycling. Microbial efficiency (g microbial protein/kg OM truly fermented) increased linearly ( $P = 0.03$ ) as season advanced (12.8 in late June to 21.7 in mid-November). Results

indicate that dietary N declines with advancing season. In addition, OM digestion declines with advancing season and N-recycling was more important later in the season when forage N declines. Microbial efficiency appears to increase with advancing season.

**Key Words:** Native Range, Intake, Microbial Efficiency

**238 Effects of degradable intake protein on forage utilization and performance of periparturient beef cows fed native prairie hay.** W. W. Dvorak\*, M. L. Bauer, J. S. Caton, and G. P. Lardy, *North Dakota State University, Fargo*.

Thirty-two Angus crossbred cows ( $670 \pm 60$  kg initial wt) were used to evaluate effects of degradable intake protein (DIP) supplementation on forage use and performance of beef cows fed native prairie hay. Treatments were control (C; corn-based supplement), urea (U), steep liquor (L), and sunflower meal (S) based supplements. Supplements were fed at 0.28, 0.28, 0.296, and 0.296% of BW during gestation, and 0.589, 0.598, 0.625, and 0.633% of BW during lactation for C, U, L, and S, respectively. All supplements provided similar energy, (NE<sub>m</sub>; 2.09 Mcal/kg). Corn-based control supplements provided 44.0 g/kg DIP during gestation and 44.9 g/kg DIP during lactation. Protein supplements were formulated to provide 131.6 g/kg DIP during gestation and 116.2 g/kg DIP during lactation. Intake of forage was measured daily during six 7-d collection periods, which represented mo 7, 8, and 9 of gestation and mo 1, 2, and 3 of lactation. Prairie hay (7.2% CP) was offered daily for ad libitum consumption. Cow weights were determined from a 3-d average weight and condition-scores were taken on d 7 for each period. Milk production was determined using the weigh-suckle-weigh method. Forage intake was similar among treatments and greater during lactation compared with gestation (2.50 vs. 1.79% of BW, respectively). Forage digestion and calf performance were unaffected ( $P > 0.10$ ) by supplementation. There was a time x treatment interaction ( $P = 0.02$ ) for cow BW. After cows were fed DIP for two months U and S were heavier ( $P < 0.10$ ) than C. Cows fed L were heavier ( $P < 0.11$ ) than C after three months. Milk production was greater for DIP supplemented cows compared to C cows ( $P = 0.02$ ; 9.5 vs. 7.1 kg/d, respectively). These data suggest that DIP supplementation may improve body weight and milk production in beef cows consuming native prairie hay.

**Key Words:** Protein Supplementation, Beef Cows, Degradable Intake Protein

**239 Performance of heifers fed a corn silage based diet and supplemented with soybean meal versus distillers dried grains plus solubles.** J. B. Corners\* and J. E. Williams, *University of Missouri-Columbia*.

A study was conducted using 63 Angus crossbred heifers ( $234.5 \pm 18.97$  kg) to compare Distillers Dried Grains with Solubles (DDGS) versus Soybean Meal (SBM) as a supplemental protein source. Animals were assigned to three treatments, which were SBM and two levels of DDGS, fed as a top-dressed supplement. Treatments were formulated to provide .30 kg SBM (12.5% CP, 1.08 Mcal NEg/kg; SBM), .30 kg DDGS (11.7% CP, 1.08 Mcal NEg/kg; LDDGS) and .76 kg DDGS (12.5% CP, 1.10 Mcal NEg/kg; HDDGS). The basal diet consisted of corn silage (22.2% DM, 8.61% CP, .79 Mcal NEg/kg), soyhulls and corn. Data were analyzed as a split plot design, while overall data were analyzed as a randomized block design (pen was the experimental unit). The ADG for the HDDGS group was numerically greater ( $P < .13$ ) than SBM, while ADG was similar ( $P > .64$ ) for the SBM and LDDGS groups. During the 112-day study, DMI ( $P > .74$ ) and F:G ratio ( $P > .24$ ) did not differ. Numerically higher ADG and numerically improved F:G ratio created a lower cost of gain ( $P < .11$ ) for the HDDGS treatment compared to the SBM group. An in situ study was conducted with two mature Angus cows consuming the test basal diet and a mixture of .45 kg SBM and .45 kg DDGS. The DDGS and SBM (4.0g in triplicate) were placed in Dacron bags and incubated up to 48 hours. The DM ( $P < .03$ ) and N ( $P < .02$ ) disappearance for SBM were increased compared to DDGS. These results revealed that the greater amount of protein escaping ruminal degradation is potentially available for utilization in the small intestine, and improved ADG in the High DDGS treatment. Based on findings, DDGS is an economically viable replacement for SBM in a corn silage based diet for growing heifers.

Item	SBM	LDDGS	HDDGS	SE	P<
ADG, kg/d	1.23 <sup>a</sup>	1.20 <sup>a</sup>	1.34 <sup>b</sup>	0.034	.13
DMI, kg/d	7.70	7.72	7.99	0.277	.74
F:G Ratio, kg/kg	6.26	6.43	5.96	0.083	.24
Cost/100 kg Gain	61.82 <sup>a</sup>	58.96 <sup>a</sup>	55.80 <sup>b</sup>	1.297	.11

<sup>a,b</sup>Values in rows not sharing a common superscript are different ( $P < .13$ ).

**Key Words:** Cattle, Distillers Grains

**240 Effect of restricted forage intake on ruminal disappearance of a blood meal, feather meal and fish meal supplement.** E. J. Scholljegerdes\*, B. W. Hess, and P. A. Ludden, *University of Wyoming, Laramie, Wyoming.*

Six Angus-cross cattle (average initial BW = 589 kg) fitted with ruminal cannulae were used to determine in situ disappearance of a ruminally undegraded protein supplement. Cattle were fed chopped (2.54 cm) bromegrass hay (8.9% CP) at one of three percentages of maintenance intake (30%, 55%, 80%) and a ruminally undegraded protein supplement (6.8% blood meal, 24.5% feather meal, and 68.7% fish meal) formulated to balance metabolizable protein across all levels of hay consumption. Adaptation to experimental diets was 7 d. On d 8, 50- $\mu$ m in situ bags containing 5 g of protein supplement were inserted into the rumen and then removed at 3, 6, 9, 12, 15, 18, 24, 36, and 48 h after insertion. Non-linear regression models were used to determine protein fractions A and B and protein degradation rate. Effective ruminal degradation was estimated using a combination of this experiment's non-linear regression data and previously determined fluid passage rates for the respective forage intake levels. Ruminally undegraded protein was not different ( $P = 0.16$  to 0.49) across treatments at 3, 6, 9, and 18 h. Increasing forage intake from 30 to 80% of maintenance resulted in a linear increase ( $P \leq 0.05$ ) in ruminally undegraded protein at 12, 15, 24, and 36 h. Dietary treatment had no effect ( $P = 0.30$ ) on protein fractions A and B; however, protein degradation rate declined linearly ( $P = 0.03$ ) as forage intake was increased from 30 to 80% of maintenance. Therefore, effective ruminal degradation decreased (linear,  $P = 0.01$ ) from 50.8 to 40.9% as forage intake increased from 30 to 80% of maintenance. Corresponding estimates of ruminally undegraded protein were 49.2, 56.5, and 59.1% for the 30, 55 and 80% of maintenance intake treatments, respectively. Restricting dietary intake can reduce the quantity of N that escapes ruminal degradation. Tabular estimates of ruminally undegraded protein are not appropriate for formulating diets to balance metabolizable protein in beef cattle consuming limited quantities of forage.

**Key Words:** Cattle, Undegraded Protein, Intake

**241 Effects of high linoleic safflower seed supplement to gestating ewes on survivability of lambs.** H. B. Encinias\*, T. C. Faller, M. L. Bauer, and G. P. Lardy, *North Dakota State University, Fargo, ND, USA.*

Lamb survival during periods of cold weather can be a problem in northern climates. Prepartum safflower seed supplementation for ewes was investigated during two consecutive years (avg high and low temp: 2.6,-9.8°C) and effects on lamb survival and performance were analyzed. One hundred twenty-two and 112 gestating ewes (78.7  $\pm$  0.6 kg initial wt) were allotted randomly to one of two dietary treatments (4 pens/treatment). Ewes were fed alfalfa-based, isocaloric and isonitrogenous diets containing either 2.8 (LF) or 5.7% (HF) dietary fat beginning approximately 45 d prepartum. Rolled safflower seeds (32% fat; 80% linoleic acid) were used as the fat source. Solvent extruded safflower meal was used as protein source in LF and energy was balanced with corn. Initial and final ewe body condition and weights, birth weights, lamb mortality, and weaning weights were measured. Mortality was separated by cause: born dead, starvation, or pneumonia. Pregnancy rate, mortality, and weaning rate data were analyzed with square root transformation. Means and 95% confidence intervals were squared for reporting. Initial (3.66  $\pm$  0.03;  $P = 0.45$ ) and final (3.91  $\pm$  0.02;  $P = 0.46$ ) body condition were similar for LF and HF supplemented ewes. There was no difference in initial (78.7  $\pm$  0.6;  $P = 0.25$ ) or final (95.0  $\pm$  0.9;  $P = 0.22$ ) BW. Number of lambs born per ewe was similar across treatments (1.70  $\pm$  0.12;  $P = 0.13$ ). Lambs weighed 5.6  $\pm$  0.1 kg at birth ( $P = 0.24$ ). More lambs ( $P = 0.03$ ) from HF supplemented dams survived (88.3 vs 78.0  $\pm$  6.5%) and less tended ( $P = 0.07$ ) to die from pneumonia (0.0 vs 0.7  $\pm$  0.5%). Ewes receiving LF had more ( $P =$

0.03) lambs die due to starvation (13.7 vs 4.2  $\pm$  5.8%). Lambs born dead were similar ( $P = 0.40$ ) across treatments (2.2  $\pm$  3.7%). Weaning weights were similar (18.5  $\pm$  0.7 kg;  $P = 0.18$ ). High fat ewes weaned more lambs per ewe (1.5 vs 1.2  $\pm$  0.001;  $P = 0.03$ ) and tended ( $P = 0.12$ ) to wean more lamb weight per ewe (24.9 vs 21.5  $\pm$  1.5 kg). High linoleic safflower seeds fed during gestation may be beneficial in improving lamb survivability.

**Key Words:** Safflower, Supplementation, Lamb Survival

**242 Urinary allantoin as an estimate of microbial protein synthesis.** M. Lamothe\*, T. Klopfenstein, D. Adams, J. Musgrave, and G. Erickson, *University of Nebraska-Lincoln.*

Sixteen primiparous March-calving cows were randomly assigned to upland native range or subirrigated meadow in the Nebraska Sandhills to determine microbial protein synthesis (BCP) by using urinary allantoin excretion as a marker. Urine and diet samples were collected from May to September. Spot urine samples were taken from each cow for five days each month. Urinary creatinine excretion was used as a marker of total urine excretion. Diet samples were taken with esophageally-fistulated cows and analyzed for in vitro dry matter digestibility (IVDMD, %). The NRC (1996) model was used to predict BCP production and intake. Actual body weights and IVDMD values were used as inputs. Cow weights increased from 410 kg in May to 500 kg in December. The table below shows the decrease in IVDMD as forage matured. The BCP production estimated by allantoin decreased with advancing season ( $P < 0.001$ ). The values were significantly higher for cows grazing meadow than range ( $P < 0.05$ ). The NRC model estimated decreasing BCP production from May to September for both meadow and range. The BCP predicted by allantoin excretion was well related to the BCP predicted by the NRC model ( $R^2 = .60$ ). Allantoin has potential to be a useful tool to estimate BCP production in grazing cattle.

	May		June		July		Aug		Sept	
Item	M <sup>a</sup>	R <sup>a</sup>	M	R	M	R	M	R	M	R
IVDMD	70.2	67.7	67.3	63.6	59.0	61.8	57.2	55.8	50.3	52.5
Allantoin <sup>a</sup>	41.5	34.9	47.1	38.8	49.4	46.0	19.4	21.7	23.9	20.5
BCP <sup>b</sup>	1163	945	1397	1122	1495	1350	605	559	645	546
BCP <sup>c</sup>	964	922	994	895	713	820	644	597	434	491

<sup>a</sup>M=meadow, R=range, Allantoin, g/d <sup>b</sup>BCP production estimated from allantoin, g/d <sup>c</sup>BCP production estimated from NRC, 1996, g/d

**Key Words:** Beef Cows, Microbial Protein, Allantoin

**243 Effect of pasture fertilization with urea or ammonium sulfate on feed selection and feed intake in sheep.** M. Abdullah\*, S.C. Loerch, D.D. Clevenger, G.D. Lowe, and B.R. Stinner, *OARDC, The Ohio State University, Wooster.*

Due to its sulfur content, fertilization of pastures with ammonium sulfate (NH<sub>4</sub>SO<sub>4</sub>) may affect forage intake. Two experiments were conducted to evaluate the effect of fertilizing orchard grass (OG) pasture with urea or NH<sub>4</sub>SO<sub>4</sub> on feed selection and dry matter intake (DMI) by lambs. In Exp. 1, OG pasture was fertilized with 89.7 kg N/ha using either urea or NH<sub>4</sub>SO<sub>4</sub>. Twenty individually penned lambs were fed supplements (0.45 kg/d) with either high (0.743%) or low (0.215%) sulfur content 14 d preceding the test period. During the test period, lambs were given free choice access to urea and NH<sub>4</sub>SO<sub>4</sub> fertilized OG for 5 d. In Experiment 2, OG pasture was fertilized with 134 kg N/ha using NH<sub>4</sub>SO<sub>4</sub> or urea. Twenty four lambs (2/pen) were fed either a low or high sulfur diet as in Experiment 1, but the supplementation continued through out the test period of 5 d. During the test period, the lambs were fed OG fertilized either with urea or NH<sub>4</sub>SO<sub>4</sub>. In Exp. 1, there were no differences ( $P > 0.05$ ) due to low or high sulfur background on selective consumption of OG fertilized with urea or NH<sub>4</sub>SO<sub>4</sub>. Total DMI however, was lower (0.74 vs. 1.10 kg/d;  $P < 0.05$ ) in high as compared to low sulfur background lambs. Dry matter intake by lambs fed the NH<sub>4</sub>SO<sub>4</sub> fertilized forage increased ( $P < 0.01$ ) from d1 (31.6% of total forage intake) to d5 (70.5% of total forage intake) irrespective of the sulfur background. Mean sulfur contents of the pastures differed ( $P < 0.01$ ) due to fertilizer source (0.346% S for urea vs. 0.488% S for NH<sub>4</sub>SO<sub>4</sub>). In Exp. 2, there was no difference ( $P > 0.05$ ) in DMI by the lambs due to sulfur background (1.44 vs. 1.40 kg/d for high vs. low sulfur background, respectively) or between lambs fed either urea or NH<sub>4</sub>SO<sub>4</sub> fertilized forage (1.39 vs. 1.45 kg/d, respectively). NH<sub>4</sub>SO<sub>4</sub>

can be used as pasture fertilizer without affecting forage palatability and feed intake by sheep.

**Key Words:** Pasture Fertilization, Urea, Ammonium Sulfate

**244 Using orchardgrass and endophyte-free fescue versus infected fescue overseeded on bermudagrass for cow herds: year 2.** D. A. Scarbrough<sup>1</sup>, W. K. Coblenz<sup>\*1</sup>, K. P. Coffey<sup>1</sup>, T. F. Smith<sup>2</sup>, J. B. Humphry<sup>1</sup>, D. S. Hubbell, III<sup>2</sup>, J. K. Martin<sup>2</sup>, J. E. Turner<sup>1</sup>, K. F. Harrison<sup>2</sup>, and D. H. Hellwig<sup>1</sup>, <sup>1</sup>University of Arkansas, Fayetteville, <sup>2</sup>Livestock and Forestry Branch Station, Batesville.

On January 11, 2000, a trial was initiated to compare the production potential of spring-calving cow-calf pairs grazing 4-ha pastures of either endophyte-free fescue (FF), or orchardgrass (OG) overseeded into bermudagrass sods versus cow-calf pairs grazing previously established mixed pastures of infected fescue (IF) and common bermudagrass. Two rotation schemes (twice weekly = HIGH; twice monthly = LOW) have been established for FF and OG pastures; IF pastures are being managed on a LOW rotation schedule only. This project was supported by grant number 2001-35209-10079 from the USDA/NRICGP Agricultural Systems Program. For the second year of this study (2001), grazing treatments did not affect cow BW at calving ( $P=0.08$ ) or breeding ( $P=0.83$ ), but affected BW at weaning ( $P=0.04$ ). Body condition scores of cows at calving, breeding, and weaning were not affected ( $P\geq 0.11$ ) by grazing treatments. In contrast, grazing treatments affected actual ( $P=0.01$ ) and 205-d adjusted ( $P<0.01$ ) weaning weights of calves. Adjusted 205-d weights of calves weaned from FF-HIGH pastures were numerically the lightest (221 kg), but did not differ ( $P\geq 0.28$ ) from weights of calves grazing FF-LOW or IF-LOW pastures. Calves weaned from OG-HIGH pastures had the heaviest ( $P<0.05$ ) 205-d adjusted weaning weights, which were in excess of 270 kg. Calves weaned from OG-LOW pastures had adjusted weaning weights that were intermediate (247 kg) between OG-HIGH and all fescue pastures. Forage availability and percentages of desired cool-season grasses (IF, FF, or OG) in the sward were not affected ( $P\geq 0.67$ ) by grazing treatments. Overseeded perennial cool-season grasses may provide opportunities to improve cow-calf performance for beef producers in Arkansas.

**Key Words:** Fescue Toxicosis, Weaning, Rotational Grazing

**245 Storage structure and density affects the VFA profile of corn silage and hay crop silage.** P. A. Porter<sup>\*1</sup>, R. J. Marfilus<sup>2</sup>, M. A. Klemme<sup>2</sup>, D. F. Schueller<sup>2</sup>, and S. L. Gunderson<sup>3</sup>, <sup>1</sup>Land O'Lakes, Webster City, Iowa/USA, <sup>2</sup>CP Feeds, LLC, Valders, Wisconsin/USA, <sup>3</sup>University of Wisconsin Extension, Manitowoc, Wisconsin.

55 corn silage (CS) and 52 hay crop silage (HCS) samples were taken from commercial dairies in eastern Wisconsin in 2000. 7 CS and 10 HCS samples were from Ag Bags; the remaining samples were from bunker silos. As fed and DM densities (AFD, DMD) and VFA concentrations were measured. For CS, bunker silos had relatively higher AFD, DMD, higher % lactic acid (L), % total VFA (tVFA) and lower pH compared to bags; for HCS, bunker silos had slightly higher AFD, DMD, % butyric acid (B) and lower L and tVFA when compared to bags (Table 1). The fermentation profile for bunker CS was slightly more favorable than that in bags, probably related to lower %DM and higher density. HCS in bags had a more favorable profile than did bunker HCS. Compared to HCS, CS had lower %DM, pH and B and higher L and tVFA. A minority of samples met the criteria of well-fermented forage:  $>70\%$  L as a % of tVFA (L/tVFA),  $<2\%$  acetic (A) and  $<1\%$  B (Table 1). Correlation coefficients were developed for the forages stored in bunker silos. For both forages, AFD and L, A and P, P and B, P and NH<sub>3</sub>-N were positively correlated. Selected HCS correlations: %DM & L ( $P=.02$ ,  $R^2=-.36$ ), %DM & tVFA (.0001,  $-.84$ ), %DM & A (.0001,  $-.74$ ), %DM & P (.0004,  $-.52$ ), %DM & B (.01,  $-.42$ ), %DM & NH<sub>3</sub>-N (.001,  $-.48$ ); AFD & tVFA (.0001,  $.71$ ); pH & L, L/tVFA or B (.0001,  $-.61$ ,  $-.71$ ,  $.79$ , respectively); B & NH<sub>3</sub>-N (.0001,  $.84$ ). Selected CS correlations: %DM & pH (.05,  $.29$ ), %DM & tVFA (.0002,  $-.51$ ), %DM & L (.006,  $-.39$ ); pH & AFD (.001,  $-.49$ ), pH & DMD (.01,  $-.36$ ), pH & L (.0001,  $-.83$ ), pH & tVFA (.01,  $-.37$ ); A & P (.0001,  $.61$ ), A & L/tVFA (.0001,  $-.86$ ).

	% samples with:							
	% DM	AFD <sup>1</sup>	DMD <sup>1</sup>	pH	L	B	tVFA	L
CS:								
Bunker	36.0	41.2	14.6	4.0	5.2	.13	8.3	63
Bag	41.0	25.1	9.8	4.2	4.4	.10	6.9	64
HCS:								
Bunker	41.5	37.7	15.0	5.0	4.3	.73	7.8	57
Bag	38.5	35.3	13.3	4.9	6.4	.10	9.2	71

<sup>1</sup>lbs/ft<sup>3</sup>

<sup>2</sup>X => 70% L tVFA, Y =< 2% A, Z =< .1% B.

**Key Words:** Fermented Forage, Volatile Fatty Acid, Bunker Silo

**246 Pasture and weaning management systems to reduce the incidence of tall fescue toxicosis in cow-calf pairs.** D. A. Scarbrough<sup>1</sup>, K. P. Coffey<sup>\*1</sup>, W. K. Coblenz<sup>1</sup>, J. K. Martin<sup>2</sup>, J. B. Humphry<sup>1</sup>, and D. H. Hellwig<sup>1</sup>, <sup>1</sup>University of Arkansas, Fayetteville, <sup>2</sup>Livestock and Forestry Branch Station, Batesville.

Many methods have been evaluated to reduce the toxic effects of grazing infected fescue (IF) pastures, but diluting those with non-infected forage species appears to be the most effective. A trial was initiated in April 2000 to evaluate effects of pasture rotation frequency (twice weekly = HIGH vs. twice monthly = LOW) and weaning date (early April vs. late May) on performance of fall-calving cow-calf pairs grazing IF pastures overseeded with crabgrass, lespedeza, red clover, and white clover. This project was supported by grant number 2001-35209-10079 from the USDA/NRICGP Agricultural Systems Program. Cow BCS was not affected ( $P\geq 0.46$ ) by treatments at calving (6.8), but was 0.3 units higher ( $P<0.01$ ) at breeding for cows grazing pastures at the LOW rotation. Pasture rotation and weaning date did not affect calving date ( $P\geq 0.38$ ), ADG ( $P\geq 0.47$ ), or 205-d weaning weights ( $P\geq 0.56$ ) of calves (mean values = October 1, 0.95 kg, and 228 kg, respectively). Late-weaned calves weighed 49.8 kg more ( $P<0.01$ ) than early-weaned calves, but weights were not affected ( $P=0.94$ ) by pasture rotation. At their respective weaning dates, calves were transported to a local auction facility, handled by routine procedures, held overnight, and then transported back to the research station. Pasture rotation did not affect ( $P\geq 0.16$ ) calf shrink percentages at any time between transportation to and from the auction facility. Total shrink losses were 1.25 percentage units higher ( $P=0.05$ ) for late-weaned calves than for early-weaned calves. To date, forage species composition has not been affected by pasture rotation ( $P\geq 0.69$ ) or weaning date ( $P\geq 0.09$ ). Results from the first calving cycle show little improvement in animal performance due to pasture rotation and weaning management, but trends may change as data from subsequent calving cycles are collected.

**Key Words:** Tall fescue, Cattle, Forage management

**247 Effect of carbohydrate types and supplemental degradable intake protein sources on low-quality forage utilization by beef steers.** J. I. Arroquy<sup>\*</sup>, R.C. Cochran, T.A. Wickersham, and D.A. Llewellyn, Kansas State University.

A trial was conducted to assess the impact of type of supplemental carbohydrate (CHO) and source of degradable intake protein (DIP) on low-quality forage utilization. Twelve ruminally fistulated beef steers (BW = 500 kg) given ad libitum access to tallgrass-prairie hay (5.3%CP, 74.8%NDF) were used in a 12-treatment, 2-period crossover experiment. Steers were subjected to two 20-d periods (11 d of adaptation) which included periods for intake and total fecal collection, ruminal evacuation, and monitoring ruminal fermentation. Treatments were arranged as a 2 x 6 factorial and consisted of two different CHO types (fed at 0.16% of initial BW) each offered with an equal amount of DIP (0.087% of initial BW) but with six different proportions of nonprotein nitrogen (NPN) and true protein as sources of DIP. The CHO types were starch and dextrose. The different proportions of the two sources of N contributing to the DIP were 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 % of supplemental N as sodium caseinate vs urea, respectively. Treatments were ruminally dosed once daily. No CHO x DIP source interactions were significant. Forage OM and total DOM intake increased linearly ( $P < 0.05$ ) in response to increased supplemental true protein. However, CHO type did not affect intake (OM,  $P = 0.25$ ; DOM,  $P = 0.23$ ). Digestibility of OM and NDF was greater ( $P = 0.05$  and  $P = 0.06$ , respectively) when dextrose was provided compared with starch. Solid passage rate

increased in a quadratic manner ( $P = 0.06$ ) in response to increasing supplemental true protein, but was slower ( $P = 0.02$ ) for dextrose than starch. In conclusion, while the CHO types evaluated did not interact with source of supplemental DIP with regard to effects on intake and digestion, both factors exerted independent effects on these characteristics. Forage digestibility was affected by the provision of sugar vs starch, whereas the relative proportion of true protein vs NPN in the supplemental nutrients affected forage intake.

**Key Words:** Carbohydrate, Protein, Beef Cattle

**248 Self-fed wheat middlings in backgrounding diets for beef heifers.** T.C. Gilbery<sup>\*1</sup>, G.P. Lardy<sup>1</sup>, B. Kreft<sup>2</sup>, J. Dhuyvetter<sup>3</sup>, and M.L. Bauer<sup>1</sup>, <sup>1</sup>North Dakota State University, Fargo, <sup>2</sup>Streeter, <sup>3</sup>Minot.

Wheat middlings are a relatively high in CP compared with other cereal grains in North Dakota backgrounding operations. Wheat middlings contain higher concentrations of digestible fiber than corn or barley, making them favorable for self-feeding. One hundred two crossbred heifers (333.7 ± 39.1 kg initial BW) were used in backgrounding study to evaluate self-fed vs. mixed diets containing wheat middlings for a 73 d period. Variables of interest were dry matter intake, average daily gain, and feed efficiency. The dietary treatments were: 1) totally mixed ration (TMR) and 2) self-fed wheat middlings-based diet. The TMR contained (DM basis) 48.25% grass hay, 48.25% wheat middlings, and 3.5% supplement. The self-fed diet consisted of ad libitum grass hay and self-fed wheat middlings. Hay in the self-fed treatment was fed as round bales in bale feeders. The wheat middlings were offered in a portable creep feeder mixed with a supplement (93.24% wheat middlings and 6.76% supplement; DM basis). Both diets were formulated to provide adequate calcium levels for a Ca:P ratio of 1.5:1. Initial and final weights were recorded, a daily record of feed offered was maintained,orts were collected and weighed as needed. Performance data were analyzed using the GLM procedure of SAS (6.11). There was no significant difference between treatments for total feed intake (11.13 ± 0.15 kg;  $P = .36$ ), average daily gain (.76 ± 0.03 kg;  $P = .79$ ), or feed efficiency ( 68.5 ± 3.1 g/gain per kg/feed;  $P = .94$  ). Hay consumption was higher for the TMR treatment (5.42 vs. 4.44 kg;  $P = 0.01$ ), and wheat middling intake was higher on the self-fed diet (6.59 vs. 5.81 kg;  $P = 0.0001$ ). Feeding wheat middlings may be a practical way to background beef cattle at moderate rates of gain.

**Key Words:** Heifers, Backgrounding, Wheat Middlings

**249 Year round grazing systems for fall- and spring-calving beef cows: winter grazing management.** N. A. Janovick\* and J. R. Russell, Iowa State University.

Winter feeding systems utilizing fall- or spring-calving beef cows were compared over 165 d in 3 yr. In a fall-calving winter grazing system, six cows with fall-born calves strip-grazed duplicate 6.1-ha stockpiled tall fescue-red clover (TFRC) pastures. In a spring-calving winter grazing system, six cows in mid-gestation strip-grazed duplicate 6.1-ha corn crop residue (CCR) pastures followed by strip-grazing in duplicate 6.1-ha smooth bromegrass-red clover (SBRC) pastures. In a drylot system, six spring-calving cows were allotted to duplicate drylots. Spring- and fall-calving cows were fed hay as needed to maintain mean body condition scores (BCS) of 5 and 3, respectively. During summer in the TFRC and SBRC pastures used for winter grazing, first-cutting forage was harvested as large round bales, forage regrowth was grazed for 65 d, and forage was fertilized with 44.9 kg N/ha before stockpiling. For the drylot system, first-cutting forage was harvested as large round bales from 5.1 to 6.1 ha in duplicate smooth bromegrass-orchardgrass-birdsfoot trefoil pastures. All cows and calves were weighed at initiation of grazing in October, in January and March and at termination of grazing in April. Cow BCS were determined visually biweekly. Cows in the drylot system lost less ( $P < .05$ ) BCS after calving compared to spring-calving cows in the winter grazing system. However, cows in the drylot system had a greater ( $P < .05$ ) total loss of BCS over winter compared to cows in the winter grazing system. There were no differences ( $P > .05$ ) in initial BCS or in the seasonal change in BCS between fall-calving cows in the winter grazing system and spring-calving cows in either the winter grazing or drylot systems. Spring-calving cows in the drylot system required 1700 kg DM more hay/cow ( $P < .05$ ) than the mean of spring- and fall-calving cows in the winter grazing system. Hay balance (kg hay produced/cow - kg hay fed/cow) of cows in the drylot system was 1244

kg /cow greater ( $P < .05$ ) than the mean of spring- and fall-calving cows in the winter grazing systems.

**Key Words:** Beef Cattle, Winter, Grazing

**250 Effect Of Creep Feeding Pressed Block or Salt-Limited Pellets To Beef Calves.** T.C. Gilbery<sup>\*1</sup>, M.H Knight<sup>1</sup>, G.P. Lardy<sup>1</sup>, B. Kreft<sup>2</sup>, J.S. Caton<sup>1</sup>, and R. Hall<sup>3</sup>, <sup>1</sup>North Dakota State University, Fargo, <sup>2</sup>Central Grasslands Research Center, Streeter, <sup>3</sup>Cooperative Research Farms.

A study was conducted to evaluate form of creep feed diets fed to nursing beef calves. Treatments were: control (CON; no creep), pressed blocks, (BLK; 26% CP; weight = 15 kg) and salt-limited pellets (SLP; 26% CP). Cows with calves (n = 118; initial BW = 604 ± 11 kg and 60 ± 2.8 kg, respectively) were allotted to 12 native pastures. The SLP and BLK diets were formulated using soybean meal, distiller's grain, and wheat middlings as the major ingredient. Calves were initially offered SLP containing 16% salt from d 0 to 29 and calves refused to consume the creep feed; therefore, salt inclusion was reduced to 0% from d 30 to 53 to encourage intake, which then averaged 1.46 kg/d (DMB). During the final 30 days, salt was added back to the SLP supplement; from d 54 to 69 the SLP treatment contained 8% salt and intake averaged 1.67 kg/d (DMB), and from d 70 to 85 inclusion was increased to 16% salt and average intake decreased to 1.20 kg/d (DMB). Feed intake remained relatively constant for the pressed block diet throughout the trial (Avg. intake = 0.55 kg/d). Calves fed creep gained more weight (102.4 vs 93.3 ± 2.6 kg;  $P = 0.02$ ) than calves not receiving creep. No difference ( $P = 0.36$ ) in calf weight gain between BLK and SLP was noted. Cow body condition score and weight changes were not different ( $P = 0.13$  and 0.70, respectively) among treatments. Dry matter intake was not different for BLK when compared to the SLP creep across the entire trial ( $P = 0.34$ ). Pressed blocks may be used to deliver moderate CP creep feeds to nursing beef calves. Salt should be introduced gradually in creep feeds to avoid feed aversions.

**Key Words:** Creep, Blocks, Salt

**251 Year round grazing systems for fall- and spring-calving beef cows: summer grazing management.** N. A. Janovick\* and J. R. Russell, Iowa State University, Ames.

Two summer forage management systems for Angus-cross cows were evaluated over 3 yr. In April 1999, six spring-calving cows with calves in a minimal land (ML) system were rotationally stocked on 2.0 to 3.0 ha of duplicate 8.1-ha smooth bromegrass-orchardgrass-birdsfoot trefoil (SB-OG-BFT) pastures for 58 d. Forage from the remaining 5.1 to 6.1 ha was harvested as first-cutting hay and these paddocks were incorporated into the rotational stocking system after 28-d regrowth. In a year round (YR) system, six spring-calving cows with calves and 12 stocker cattle lead-grazed paddocks of duplicate 8.1-ha SB-OG-BFT pastures by rotational stocking before six pregnant fall-calving cows for 55 d. Forage from duplicate 6.1 ha smooth bromegrass-red clover (SB-RC) and tall fescue-red clover (TF-RC) pastures was harvested as first-cutting hay from 3.0 to 6.1 ha. These pastures were strip-grazed by spring-calving cows with calves and fall-calving cows for 45 d, while stocker cattle remained in the SB-OG-BFT pastures. Thereafter, stocker cattle were removed and spring- and fall-calving cows were rotationally stocked in the SB-OG-BFT pastures for 80 d. Average daily gains of spring calves did not differ ( $P > .2$ ) between systems and were greater ( $P < .01$ ) than fall calves in the YR system (1.1 vs .9 kg/d). Total growing animal production (calves + stocker cattle) in the ML and YR systems were 143 and 130 kg/ha perennial pasture ( $P > .07$ ). Spring-calving cows in the YR system lost more body condition ( $P < .04$ ) and BW ( $P < .01$ ) over the summer grazing season compared to spring-calving cows in the ML system. Compared at similar physiological states, fall-calving cows lost less BW compared to either group of spring-calving cows ( $P < .01$ ) approximately 30 d pre-calving to 21 d post-calving. Over 3 yr, more hay was produced in the ML compared to the YR system expressed either as kg DM/harvested ha or kg DM/cow ( $P < .05$ ). Grazing treatment did not affect botanical composition (% of live DM) in SB-OG-BFT pastures in April and October of either year ( $P > .05$ ).

**Key Words:** Beef Cattle, Rotational Stocking, Grazing Systems

**252 Grazing potential of barley or oat forage for yearling beef heifers in the Northern Great Plains.** W. W. Poland\*, P. M. Carr, and L. J. Tisor, *North Dakota State University, Dickinson.*

Barley (*Hordeum vulgare*) forage has been shown to be higher in quality compared to oat (*Avena sativa*) forage in many agronomic experiments. Conversely, oat often produces more biomass. An experiment was designed to compare the grazing potential of barley and oat forage for yearling beef heifers. Forages were evaluated on the basis of animal performance and forage production and quality. In 2000, six 1-ha paddocks were blocked into two groups (3 paddocks per group) based upon previous cropping history and randomly allotted within group to be seeded to either barley or oat. Twenty-four bred yearling beef heifers ( $418.2 \pm 2.69$  kg;  $6.8 \pm .23$  body condition score) were then stratified by weight and randomly assigned to paddock within weight stratum (4 heifers/paddock). Heifers were turned out to graze paddocks in early June (approximately 47 d post-seeding) and grazed for 28 d. There were no differences in final BW ( $P=.15$ ) or condition score ( $P=.53$ ), ADG ( $P=.87$ ) or total gain ( $P=.87$ ). Heifers gained  $.87 \pm .07$  kg/d and produced  $95.9 \pm 7.6$  kg/ha of BW gain over the grazing period. There were no differences in cereal ( $P=.48$ ), weed ( $P=.46$ ) or overall ( $P=.29$ ) forage available for grazing between forage types. The percentage of cereal ( $P=.58$ ) contribution to overall forage mass also did not differ between forage types. On average, there was  $4338 \pm 154$  kg/ha of forage available for grazing of which  $78.2 \pm 2.5$  % was cereal. Crude protein ( $P=.20$ ), ADF ( $P=.85$ ), NDF ( $P=.30$ ), and TDN ( $P=.40$ ) concentrations did not differ with forage type. Average concentrations were  $139 \pm 6.4$ ,  $363 \pm 5.1$ ,  $579 \pm 8.6$  and  $556 \pm 3.8$  g/kg for CP, ADF, NDF and TDN, respectively. In difference to previous work, cattle performance when grazing barley or oat forage did not differ. Furthermore, forage production and quality were not affected by forage type. These data suggest that cattle can be grazed successfully on pastures annually seeded to small grain forage without regard to forage type during the summer in the Northern Great Plains.

**Key Words:** Barley, Oat, Annual Forage

**253 Influence of forage type on digestion, nutrient flow and microbial efficiency in beef steers.** T. D. Maddock\*, J. E. Leonard, M. L. Bauer, G. P. Lardy, V. I. Burke, T. C. Gilbery, and J. S. Caton, *North Dakota State University.*

Four ruminally and duodenally cannulated beef steers (BW = 419–33 kg) were used in a 4 x 4 Latin square to evaluate the effects of forage type on site of digestion, nutrient flow, and microbial efficiency. Diets, offered ad libitum, were alfalfa (ALF; 17.5% CP), brome (BRO; 8.9% CP), cornstover (CST; 3.3% CP), and native grass hay (NGH; 7.5% CP). Experimental periods were 21 d with 12 d adaptation to diet before collections began. Eight g chromic oxide was dosed twice daily. Duodenal samples were taken over a 3-day period. Fecal output was measured directly with fecal bags. Intake of OM and N differed ( $P < 0.004$ ) between treatments with CST lower than ALF, BRO, and NGH ( $2597$  vs  $7374$ ,  $6577$ ,  $5892 \pm 374$  g/d OM;  $15.3$  vs  $230.1$ ,  $104.9$ ,  $77.2 \pm 23.1$  g/d N, respectively). Duodenal OM microbial and non-microbial flow was lower ( $P < 0.10$ ) for CST than ALF, BRO, and NGH ( $324.5$  vs  $694.2$ ,  $611.3$ ,  $709.5 \pm 80.8$  g/d microbial;  $1583$  vs  $3218$ ,  $2933$ ,  $2821 \pm 337$  g/d non-microbial, respectively). Total and non-microbial N flow to the duodenum was higher ( $P < 0.10$ ) for ALF ( $181.3 \pm 18.3$ ;  $117.1 \pm 14.6$  g/d) than other treatments and CST ( $55.2 \pm 14.2$ ;  $30.9 \pm 11.3$  g/d) was lower ( $P < 0.10$ ) than BRO ( $117.2 \pm 14.2$ ;  $68.7 \pm 11.3$  g/d) and NGH ( $102.1 \pm 14.2$ ;  $48.0 \pm 11.3$  g/d). Microbial duodenal N flow was lower ( $P < 0.10$ ) for CST than ALF, BRO, and NGH ( $24.2$  vs  $64.2$ ,  $48.5$ ,  $54.1 \pm 6.4$  g/d, respectively). Microbial efficiency was unaffected ( $P = 0.19$ ) by treatment. Total tract OM digestion did not differ ( $P = 0.50$ ) among treatments. Digestion was measured ruminal and post-ruminal and CST had lower N digestion compared to other treatments ( $P < 0.10$ ). Both apparent and true ruminal OM digestion was lower ( $P < 0.08$ ) for CST than ALF, BRO, and NGH ( $22.8$  vs  $49.0$ ,  $47.3$ ,  $40.2 \pm 7.4$  % apparent;  $36.1$  vs  $58.2$ ,  $56.4$ ,  $52.4 \pm 5.7$  % true, respectively). Low quality forages such as CST may benefit from protein supplementation as a means to stimulate intake, digestion, and microbial efficiency.

**Key Words:** Forage, Steer, Digestion

**254 Methods to estimate DIP content and nutritive value of grazed Old World Bluestem and Tall Grass prairie across the calendar the calendar year.** R. Basurto\*, H. Purvis II, T. Bodine, and G. W. Horn, *Oklahoma State University.*

In trial one, in situ methods and a lab method (STREP) were compared to in vivo values obtained from digestion trial where six crossed multi-cannulated Angus steers were fed ad libitum Alfalfa, Bermuda or Prairie hay in a replicated 3x3 Latin square design. The in situ methods involved two single point estimations of nitrogen disappearance at 16 and 20 h (16IS and 20IS) and two methods using neutral detergent insoluble nitrogen pool (NDIN) times ( $kp / (kp+kd)$ ), where kd was slope of in situ digestion equation of NDIN and kp was passage particle rate estimated by using ADIA as marker. NDIN was calculated as intercept of digestion equation (NDIN-1) or lab value determined directly in lab (NDIN-2). In vivo DIP values were 84.3, 67.5 and 49.7 % of total CP for Alfalfa, Bermuda, Prairie hay respectively. A method \* forage interaction was detected ( $P < .01$ ). DIP values of 16IS, 20IS and NDIN-2 for prairie hay differed with ( $P < .01$ ) respect to in vivo values. The DIP values for NDIN-1, NDIN-2 and STREP did not differ of those in vivo. Considering this and that STREP method is simple to attain in laboratory, it was utilized to determine changes in adequacy of supply of degradable protein (DIP) of Old World bluestem (OWB), and Tallgrass (TG) throughout the calendar year. Forage samples were monthly collected by rumen-fistulated steers over 5 yr. The adequacy of DIP was calculated as:  $(CP * DIP; supply) / (IVOMD * 11.0\%; required)$ , where CP=crude protein, IVOMD=in vitro organic matter digestibility, DIP= S. griseus protease method (STREP) and, 11%=microbial efficiency growth. Degradable intake protein expressed as a percentage of CP ranged from 53.0 to 76 % and 55 to 70% for OWB and TG throughout calendar year. Content of CP of forages was highest in the early spring and decreased into fall and winter. The adequacy of DIP supply in both forages was deficient respect with to available energy from Sep to Mar period. Overall, both NDIN and STREP appear to estimate in vivo DIP values adequately. Addition timing of decline DIP relation to energy in OWB and TGP is supported by the observed responses to summer and winter protein supplementation on these forages.

**Key Words:** Forage, Degradable Intake Protein, Methods

**255 Influence of potato-processing waste in beef finishing diets on intake, ruminal fermentation, site of digestion and microbial efficiency.** A. E. Radunz\*, M. L. Bauer, G. P. Lardy, and E. R. Loe, <sup>1</sup>North Dakota State University, Fargo.

Four ruminally and duodenally cannulated Holstein steers (487–26.6 kg initial BW) were used in a 4 x 4 Latin square to evaluate inclusion level of potato-processing waste (PW) in finishing diets on intake, ruminal fermentation, site of digestion, and microbial efficiency. The control diet contained 82(CSB), and 3the diet at 0, 13, 27, and 4013tylosin/kg. Steers were offered diets ad libitum and adapted to diets for 9 d. Intakes were measured on d 10 to 14. Starting on d 9, Cr (8 g) was dosed ruminally every 12 h. Duodenal (200g) and fecal (200g) samples were taken every 4 h on d 11 and 12 and composited within period and steer. On d 13, Co-EDTA (200 mL) was dosed intraruminally 2 h prior to feeding and ruminal fluid was collected and pH recorded at 0, 2, 4, 6, 8, 10, and 12 h post-feeding. Linear, quadratic, and cubic contrasts were used to compare levels of PW. Dry matter intake ( $i$  0.01) with increasing PW. Liquid dilution rate tended to increase from 6.8 to 9.7 increased (linear,  $P$   $i$  0.05) and NH<sub>3</sub>-N increased (quadratic and cubic,  $P$   $i$  0.04) with increasing PW. No effect on OM disappearance ( $P$   $i$  0.15) was observed among treatments. Inclusion of PW decreased true ruminal and apparent total tract N disappearance (linear,  $P$   $i$  0.01). Bacterial CP synthesis was not different among diets ( $P$   $i$  0.6). Starch intake and ruminal starch disappearance decreased with increasing PW (linear and quadratic,  $P$   $i$  0.05). Apparent total tract starch digestibility was not different with increasing PW ( $P$   $i$  0.4). Inclusion of PW did not effect OM and starch digestibility; however, PW appears to have a lower protein digestibility than corn.

**Key Words:** Potato-Processing Waste, Cattle, Digestion

**256 Effects of harvest date and late-summer nitrogen fertilization rate on mineral concentrations of stockpiled bermudagrass forage.** D.L. Lalman<sup>\*1</sup>, A.A. Gelvin<sup>1</sup>, C.M. Taliaferro<sup>1</sup>, and J. Ball<sup>2</sup>, <sup>1</sup>Oklahoma Agriculture Experiment Station, Stillwater, <sup>2</sup>Noble Foundation, Ardmore, Oklahoma.

A randomized complete block design with 4 replications was used to test the effects of harvest date and N fertilization rate on mineral concentration of stockpiled Greenfield bermudagrass at the Eastern Research Station near Haskell, Oklahoma. Four N fertilization rates were applied on August 25, 1998 (0, 33.7, 67.3, and 134.6 kg N/ha) and forage was sampled at five 28-d intervals beginning November 5 and ending March 4. During late April, prior to the experiment, 112 kg N/ha was applied and P & K was applied as indicated by soil test. Hay was harvested from the plots during early June and again during early August. Mineral concentration was determined using an inductively coupled plasma radial spectrometer, with the exception of S, which was determined using the combustion method (Leco Model SC-432). The effects of harvest date and N fertilization rate on direction (increase or decrease) of change in forage mineral concentrations were determined using linear regression. Mean macro mineral concentration (% of DM) was 0.41, 0.19, 0.09, 0.40, and 0.03 for Ca, P, Mg, K and Na, respectively. Mean micro mineral concentration (ppm, DM basis) was 194, 24.9, 4.12, 107, 0.58 and 0.27 for Fe, Zn, Cu, Mn, Mo and S, respectively. Concentration of Na and S increased ( $P < .01$ ) with increasing N fertilization, while concentrations of Ca, Fe, Zn, Mn, and Mo declined ( $P < .02$ ). Concentrations of P and Cu were not affected ( $P > .2$ ) by N fertilization rate. There was an N fertilization rate \* harvest date interaction ( $P < .01$ ) for Mg and K. This interaction was the result of a greater increase in forage Mg and K concentration with higher rates of N fertilization during autumn compared to late winter. Forage copper concentration did not change significantly over time ( $P = .18$ ), while Zn concentration increased slightly ( $P < .01$ ) as the winter progressed. Later harvest dates were associated with decreased ( $P < .05$ ) concentrations of all other minerals. Several key macro and micro minerals are marginal to deficient in stockpiled bermudagrass forage, compared to recommended dietary mineral concentrations for beef cattle. Moreover, concentrations of most minerals decrease throughout the winter.

**Key Words:** Stockpiled Bermudagrass, Minerals, Nitrogen Fertilization

**257 Nitrogen timing and rate effects on yield and quality of drought-stressed stockpiled fescue.** J. A. Jennings<sup>\*</sup>, W. K. Coblenz, and L. J. Sandage, *University of Arkansas Cooperative Extension Service.*

Stockpiled fescue is commonly used to reduce winter hay feeding in Arkansas. Little information exists on the optimum rate or date of nitrogen application or on quality of stockpiled fescue after a severe summer drought. The objective was to evaluate three nitrogen rates applied on each of three dates for yield and quality of stockpiled fescue following a summer drought. In 1998, plots were established in fescue fields at two locations in north Arkansas. Nitrogen fertilizer was applied at 0, 45, 67, and 90 kg/ha on August 20, September 4, and September 21. Plots were harvested on December 15. Forage samples were collected monthly between October and February from the 0 nitrogen and 67 kg/ha nitrogen treatments for the September 4 application date. Forage samples were analyzed for crude protein, ADF, TDN, and nitrate. Nitrogen rate or application date did not significantly affect dry matter yield ( $P > 0.10$ ). Crude protein ( $P < 0.06$ ) and TDN ( $P < 0.07$ ) were higher for the 67 kg/ha nitrogen rate than for the 0 nitrogen rate. Forage quality declined between the October and February sampling dates. Percent crude protein was highest in October at 21.6% and was lowest in January at 16.1% ( $P < 0.001$ ). Percent TDN declined significantly from 69.6% in October to 63.1% in January ( $P < 0.001$ ). Results indicate that drought-stressed fescue is responsive to fall-applied nitrogen for forage quality, but not for yield.

**Key Words:** Fescue, Stockpiled Fescue, Forage Quality

**258 Effects of nitrogen fertilization rate and harvest date on bermudagrass quality and in situ DM and fiber degradation.** N. W. Galdamez<sup>\*1</sup>, K. P. Coffey<sup>1</sup>, W. K. Coblenz<sup>1</sup>, J. E. Turner<sup>1</sup>, D. A. Scarbrough<sup>1</sup>, J. B. Humphry<sup>1</sup>, J. L. Gunzaulis<sup>2</sup>, and M. B. Daniels<sup>2</sup>, <sup>1</sup>University of Arkansas, Fayetteville, AR, <sup>2</sup>Cooperative Extension Service.

Nutrient composition and digestibility of bermudagrass [*Cynodon dactylon* (L) Pers.] may vary depending on different management practices such as fertilization and harvest date. Bermudagrass was fertilized at four rates (0, 56, 112, and 168 kg N/ha) approximately 31 d prior to first and third harvests on May 30 and August 18, 2000 to determine in situ DM and NDF degradation. Five crossbred ruminally cannulated steers ( $421.5 \pm 21.0$  kg BW) were used to evaluate these forages in situ in a randomized complete block design with a  $2 \times 4$  (harvest  $\times$  N fertilization rate) factorial arrangement. Forage N concentration increased with increasing N rate in May ( $y = 0.0027x + 2.69$ ;  $P = 0.018$ ;  $R^2 = 0.97$ ) and August ( $y = 0.0038x + 1.82$ ;  $P = 0.016$ ;  $R^2 = 0.97$ ), but fiber concentrations did not differ ( $P > 0.05$ ) across fertilization rates. Nitrogen concentrations were higher and NDF concentrations were lower ( $P < 0.01$ ) on May 30 compared with August 18. The N fertilization by harvest date interaction was evident for the immediately soluble fraction of DM ( $P = 0.01$ ) and NDF ( $P = 0.06$ ). The DM degradation rate tended to increase ( $y = 0.00003x + 0.032$ ;  $P = 0.07$ ;  $R^2 = 0.08$ ) and effective DM degradability increased with N fertilization rate ( $y = 0.018x + 49.97$ ;  $P < 0.01$ ;  $R^2 = 0.20$ ). Likewise, rate of NDF degradation increased ( $y = 0.00004x + 0.028$ ;  $P = 0.02$ ;  $R^2 = 0.13$ ) and effective NDF degradability tended to increase ( $y = 0.010x + 37.69$ ;  $P = 0.09$ ;  $R^2 = 0.08$ ) with increasing N fertilization rate. The undegradable DM fraction was higher and the potential extent of digestion and effective degradability were lower ( $P < 0.01$ ) on August 18 compared with May 30. Therefore, N fertilization improves quality of bermudagrass marginally by increasing N concentration in the plant as well as improving the degradation rate and effective ruminal degradability of DM and NDF.

**Key Words:** Bermudagrass, In Situ, Degradation Kinetics

**259 Relative Forage Quality: an alternative to Relative Feed Value.** J. E. Moore<sup>\*1</sup> and D. J. Undersander<sup>2</sup>, <sup>1</sup>University of Florida, Gainesville, FL, <sup>2</sup>University of Wisconsin, Madison, WI.

Forage quality indices estimate voluntary intake of available energy when forage is fed alone. Relative Feed Value (RFV), used widely in the U.S., is voluntary forage DM intake (VFI, % BW) times digestible dry matter (DDM, % DM) divided by a factor (1.29) so that RFV of full bloom alfalfa = 100. Accuracy of predicted RFV values is dependent on the equations used to predict VFI and DDM from NDF and ADF analyses, respectively. The intake equation used in RFV assumes that NDF intake is a constant 1.2% BW. For grasses, however, NDF intake is not constant and NDF is not correlated closely with DMI. Also, differences between observed and predicted DDM values are often large. Therefore, new approaches for predicting VFI and available energy of forages must be considered, but it is not possible to separate RFV from the equations used to predict it. We propose Relative Forage Quality (RFQ) as an alternative to RFV in order to facilitate improvements in the accuracy of predicting forage quality. The available energy component of RFQ is TDN, rather than DDM, thus  $RFQ = (VFI, \% BW) * (TDN, \% DM) / 1.22$ . The divisor, 1.22, was developed and evaluated using two independent animal data sets. In both sets, observed RFV and RFQ were correlated ( $r = .99$ ), and the means and ranges of RFV and RFQ were similar. Predicted RFQ and RFV values for individual samples may vary greatly, however, because RFQ will use more accurate prediction equations for VFI and TDN. Potential uses of RFQ include current uses of RFV. Advantages of RFQ are: multiplying RFQ by .0122 gives an estimate of TDN intake (% BW); TDN may be converted to NE; VFI can be calculated by dividing TDN intake by TDN; and both VFI and TDN can be used as inputs for nutritional models. New equations must be used to predict VFI and TDN, and these equations should be specific for particular classes of forages. A new VFI prediction equation for grasses is:  $VFI (\% BW) = -2.318 + .442*CP - .0100*CP^2 - .0638*TDN + .000922*TDN^2 + .180*ADF - .00196*ADF^2 - .00529*CP*ADF$  (Moore and Kunkle. 1999. J. Anim. Sci. 77[Suppl. 1]:204). For TDN, a summative equation is recommended (e.g., NRC. 2001. Nutrient Requirements of Dairy Cattle).

**Key Words:** Forage, Quality, Prediction

**260 Effect of grazing corn stalks in the spring on subsequent crop yields.** C. B. Wilson\*, G. E. Erickson, T. J. Klopfenstein, and W. Luedtke, *University of Nebraska, Lincoln, NE.*

Stalk grazing is often discontinued when soils thaw because of concern about soil compaction and subsequent crop yields. However, many producers want to maintain cattle on stalk fields to reduce costs. This study was initiated to evaluate the impact of spring corn residue grazing on subsequent crop yields in a corn-soybean rotation. Tillage treatments consisting of ridge-till, fall-till, spring-till, and no-till were also evaluated. Two consecutive two year studies were conducted within two 18 ha fields near Ithaca, NE. Grazed and ungrazed treatments were superimposed on some tillage treatments and replicated within field. Crop yields were evaluated for soybeans the subsequent fall and corn two years post grazing. In the first study (Exp1) stocking rate was 0.32 ha/hd/60 d. In the second study (Exp2) stocking rate was 0.13 ha/hd/60 d. Grazing was conducted from early February to late April; 48 d in 1998, and 56 d in 1999; 75 d in 2000 and 68 d in 2001. Soybean yields from Exp1 showed a trend for treatment effects ( $P = 0.14$ ) and no year  $\times$  treatment interactions. Soybean yield on grazed treatments were actually higher than ungrazed treatments (3081.2 versus 3048.2 kg/ha;  $P = 0.02$ ). Corn yields following soybeans in Exp1 showed no effects of treatment or year  $\times$  treatment interactions. Soybean yields from Exp2 were influenced by treatment ( $P = 0.02$ ) but not year  $\times$  treatment interactions. Soybean yield on grazed treatments were higher than ungrazed treatments (4401.5 versus 4280.3 kg/ha;  $P = 0.01$ ). Corn yields following soybeans showed no effect of treatment or year  $\times$  treatment interactions. Spring and fall tillage had no significant effect on yield in either experiment. In summary, spring corn residue grazing appears to have no detrimental impacts on subsequent soybean yields or corn yield the following season. Soybean yields were surprisingly higher in grazed no-till and ridge-till treatments than other treatments suggesting that producers can maintain livestock on crop acres in the spring if soybeans are planted the subsequent growing season.

**Key Words:** Grazing, Crop Residue, Crop Yield

**261 Comparison of Dry and Liquid Protein Supplements Fed to Stocker Cattle consuming Low-Quality Native Grass: performance and digestibility.** J. S. Weyers\*, H. T. Purvis II<sup>1</sup>, C. R. Krehbiel<sup>1</sup>, D. L. Lalman<sup>1</sup>, D. A. Cox<sup>1</sup>, J. E. Moore<sup>2</sup>, and J. Harris<sup>3</sup>, <sup>1</sup>Oklahoma State University, Stillwater OK, <sup>2</sup>University of Florida, Gainesville FL, <sup>3</sup>Westway Ag, Tomball TX.

Two studies were conducted to determine the effect of differing amounts of degradable intake protein (DIP) from liquid or dry supplements on performance and digestibility by stocker cattle consuming low-quality forage. During trial 1, ruminally dosed supplements were a urea-based liquid feed formulated to provide .33 kg/d of DIP (LIQ1), a urea/feathermeal-based liquid feed formulated to provide .20 kg/d of DIP (LIQ2), or a cottonseed meal/soybean meal blend to provide .20 kg/d of DIP (DRY). Supplemented cattle had greater ( $P < .05$ ) total OM intake, total digestible OM intake, hay OM intake and fecal OM output than cattle not supplemented. Furthermore, cattle supplemented with LIQ2 had greater ( $P < .05$ ) total OM intake (4.16 kg), total digestible OM intake (2.34 kg), hay OM intake (3.53 kg) and fecal OM output (1.82 kg) than cattle supplemented with LIQ1 (3.42, 1.94, 2.79, 1.48 kg, respectively). Treatments did not affect total OM digestibility. During trial 2, supplement type and amounts were the same as trial 1. Cattle were fed 5 d/wk in individual stalls for one and no longer than four hours. Across the supplemental feeding period, average intake was only 39 and 79% of feed offered for LIQ1 and LIQ2, respectively, while no intake reductions were apparent with DRY. There were no differences ( $P > .10$ ) in initial and final body weights between treatments. Total gain and ADG were greater ( $P < .05$ ) for supplemented steers than for steers not supplemented, and steers receiving DRY had greater ( $P < .05$ ) total gains (12.77 kg) and ADG (.23 kg) than steers receiving liquid supplements (1.54 and .03, 3.02 and .05 kg for LIQ1 and LIQ2, respectively). There was no difference ( $P > .05$ ) between LIQ1 and LIQ2 for total gain or ADG. Limited intake of LIQ1 and LIQ2 during trial 2, could explain the decrease in performance compared with DRY. Relative to trial 1, these data suggest that sufficient intake of DIP from liquid supplements can increase low quality forage OM intakes. Also, different amounts and/or types of protein may influence digestion and performance.

**Key Words:** Degradable Intake Protein, Liquid Supplements, Low-Quality Forage

**262 Effect of the frequency of cracked corn supplementation on alfalfa hay utilization by growing cattle.** A.F. La Manna<sup>1</sup>, H.P. Purvis II\*<sup>1</sup>, T.N. Bodine<sup>1</sup>, G.W. Horn<sup>1</sup>, and F.N. Owens<sup>2</sup>, <sup>1</sup>Oklahoma State University, <sup>2</sup>Dupont Specialty Grains.

Two trials were conducted to study the effect of frequency of cracked corn supplementation on utilization of alfalfa hay. In Trial 1, eight ruminally cannulated crossbred steers (484kg) in a replicated 4  $\times$  4 Latin square were given ad libitum access to chopped alfalfa hay with no supplement (CONT) or with a cracked corn supplement fed at one of three frequencies: 0.5 % of body weight (BW) every day (24); 1.0% of BW every other day (48) or 1.5% of BW every third day (72). Effects of supplemental corn grain and linear and quadratic effects of feeding frequency were tested. Total organic matter intake (OMI) was greater when corn was fed every day than when corn was fed less frequently (12.64, 13.97, 12.57 and 12.17 kg OMI/day for CONT, 24, 48 and 72 respectively) and decreased linearly ( $P < .05$ ) as time interval increased. Feeding cracked corn increased ( $P < .01$ ) organic matter digestibility (OMD) (68.89, 71.69, 73.90 and 75.31% for CONT, 24, 48 and 72 respectively). Ruminal concentration of butyrate (7.63, 8.97, 9.17 and 10.64 mmol/L for CONT, 24, 48 and 72 respectively) were greater for supplemented cattle ( $P < .01$ ) and increased linearly as time interval increased ( $P < .05$ ) but the acetate to propionate ratio of ruminal fluid decreased (4.54, 4.37, 4.24 and 4.11 for CONT, 24, 48 and 72 respectively;  $P < .05$ ). In Trial 2, 60 Holstein heifers (199kg) were stratified by weight and assigned to the same four treatments in a randomized complete block design with the exception that hay was not chopped. After 90 d on trial, feeding supplemental corn increased ADG (.48, .77, .75, .62 kg/day for CONT, 24, 48 and 72 respectively;  $P < .05$ ) and ADG decreased linearly ( $P < .05$ ) as time interval between supplement feedings increased. Fed supplemental energy will have greater ADG than unsupplemented controls. Additionally less frequency of supplement increased OMD but reduced OMI, which impacted ADG.

**Key Words:** Corn Feeding Frequency, Alfalfa Hay, Cattle

**263 Effects of weaning date and protein supplementation on cow/calf productivity.** L. A. Ciminski\*, D. C. Adams<sup>2</sup>, T. J. Klopfenstein<sup>1</sup>, and R. T. Clark<sup>3</sup>, <sup>1</sup>University of Nebraska-Lincoln, Animal Science, <sup>2</sup>University of Nebraska-Lincoln, West Central Research and Extension Center, Animal Science, <sup>3</sup>University of Nebraska-Lincoln, West Central Research and Extension Center, Agricultural Economics.

Producers in order to manage cow/calf productivity, cow body condition score, and extend grazing through the winter can use weaning date and supplementation as tools. The objective of this study was to determine the long-term effects of weaning date and protein supplementation on cow body condition score, cow weight, calf performance, and pregnancy rate. A 4-year experiment was conducted to determine the effects of weaning date and supplementation on cow/calf productivity in the Nebraska Sandhills using 134 MARC II spring calving cows. Treatments were a 2 $\times$ 2 factorial design, weaning in mid-August (E) or early November (L), protein supplementation (Y) or no protein supplementation (N). Data were analyzed using the mixed procedures in SAS. Pregnancy rates for the four treatments were 96, 94, 95, and 94% for EN, EY, LN, and LY, respectively, and were not significantly different ( $P > .05$ ). Cow body condition scores and cow weights varied throughout the year as forage quality and cow requirements varied. At time of calving cow body condition scores were 4.8, 5.2, 4.0, and 4.7 (scale 1-9) for EN, EY, LN, and LY, respectively, and significantly different ( $P < .05$ ) among all treatments. Birth weight and birth date of calves were not significantly different ( $P > .05$ ) among the treatments. There was a significant main effect ( $P < .05$ ) for both weaning date and supplementation at the August weaning for the calf weights. Cows that were weaned in August or received supplement during winter grazing had calves with weights that were significantly greater ( $P < .05$ ) than those that were weaned in November or received no supplement. LY treatment had higher ( $P < .05$ ) calf weights than the LN treatment at the November weaning date. Weaning date and supplementation of cows had a significant effect on cow body condition score and weaning weights of the calves, yet no significant effect in pregnancy rate occurred.

**Key Words:** Cows, Weaning, Protein Supplementation

**264 Effect of field pea supplementation on intake, digestion, and ruminal fermentation in beef steers fed forage based diets.** J.J. Reed\*, G.P. Lardy, T.C. Gilbery, M.L. Bauer, and J.S. Caton, *North Dakota State University*.

Four ruminally and duodenally cannulated steers ( $397 \pm 55$  kg initial BW) were used in  $4 \times 4$  Latin square to evaluate the effect of field pea supplementation on intake, site and rate of digestion, ruminal fermentation, and ruminal fill in steers fed moderate quality (8.0% CP) grass hay. Diets, offered ad libitum twice daily, consisted of grass hay and four field pea supplements (22.4% CP; 0, 0.9, 1.8, and 2.7 kg daily). Steers were allowed free access to water and trace mineralized salt blocks and were adapted to diets for 9 d. On d 10 to 14, intakes were measured. Field pea and grass hay were incubated in situ, beginning on d 10, for 0, 2, 4, 8, 12, 16, 24, 36, 48, 72, and 96 h. Ruminal fluid was collected and pH recorded at -2, 0, 2, 4, 6, 8, 10, and 12 h post-feeding on d 13. Duodenal samples were taken for three consecutive days beginning on d 10 in a manner that allowed for a collection to take place every other hour for a 24 h period. Total DMI ( $7.7, 9.2, 9.3, 9.3 \pm 0.8$  kg) and OMI ( $6.7, 8.1, 8.2, 8.3 \pm 0.7$  kg) increased ( $P < 0.03$ ) and grass hay DMI ( $7.7, 8.3, 7.5, 6.6 \pm 0.8$  kg) and OMI ( $6.7, 7.2, 6.5, 5.7 \pm 0.7$  kg) decreased ( $P < 0.04$ ) linearly with increasing level of supplementation. In situ DM disappearance of field pea ( $8.8, 6.5, 5.5, 5.8 \pm 0.9$  %/h), and ruminal pH ( $6.84, 6.94, 6.76, 6.79 \pm 0.02$ ) decreased ( $P < 0.05$ ) linearly with increasing field pea supplementation. Ruminal VFA increased linearly ( $P < 0.006$ ) and total tract CP and apparent ruminal DM digestion tended to increase linearly ( $P < 0.09$ ) with increasing field pea supplementation. Total tract NDF digestion tended to change ( $P = 0.08$ ) cubically with field pea supplementation. No effects were observed ( $P > 0.11$ ) for ruminal fill, fecal output, total tract DM digestibility, total tract OM digestibility, or in situ DM disappearance of grass hay. Due to effects on forage intake and ruminal pH, field peas appear to act like cereal grain supplements in high forage diets.

**Key Words:** Field Pea, Digestibility, Supplement

**265 Drought Stressed Soybean Supplementation for Gestating Beef Cows.** J.D. Steele\*, D.L. Lalman, R.P. Wettemann, and C.K. Krehbiel, *Oklahoma Agriculture Experiment Station, Stillwater*.

This study was designed to determine the effects of feeding whole or ground drought stressed soybeans (38% CP, 16% fat, U.S. No. 4) during late gestation on production of beef cows grazing dormant stockpiled native grass. Multiparous Angus and Angus x Hereford cows ( $n=91$ ) were ranked by initial body weight and sequentially assigned to supplement treatments. Treatments were: 1) 0.91 kg whole soybeans (WSB), 2) 0.91 kg ground soybeans (GSB), 3) 1.25 kg of soybean meal and soybean hulls formulated to be iso-nitrogenous and iso-caloric to WSB and GSB (PCON), and 4) no supplement (NCON). Initial BW and body condition score (BCS) was  $557 \pm 30$  kg and  $5.25 \pm 0.14$  (1-9 scale), respectively. Supplemented cows were individually fed twice their daily feeding rate on an every other day basis. The treatment period was initiated on November 11, 2000 and continued through February 2, 2001 for a total of 88 d. All BW and BCS were recorded after a 16-hour removal from feed and water. Blood samples were collected on May 2 and May 9. Cows that had  $> 1$  ng/ml plasma progesterone were considered to be cycling at the onset of breeding (May 10). Cow served as the experimental unit. Weight change during the treatment period was  $-26.5$  kg,  $-7.9$  kg,  $+10.6$  kg, and  $-69.4$  kg for WSB, GSB, PCON, NCON, respectively and differed between each treatment group ( $P < .01$ ). Compared to nonsupplemented cows, supplemented cows had less treatment period BCS loss ( $\#0.42$  vs  $\#1.6$ ;  $P < .01$ ), greater calf birth wt ( $39.0$  vs  $35.2$  kg;  $P < .05$ ), and greater calf weaning wt ( $222.6$  vs  $203.3$  kg  $P < .05$ ). Treatment period BCS loss, calf birth wt and weaning wt did not differ among supplemented groups ( $P > .1$ ). Percent cows cycling was 21.5, 64.8, 62.5, and 24.7 for WSB, GSB, PCON and NCON, respectively ( $P < .05$ ). Pregnancy rate was 96, 95, 84, and 82, for WSB, GSB, PCON and NCON, respectively ( $P = 0.21$ ). Drought stressed soybeans are an effective supplemental protein and energy source for gestating beef cows.

**Key Words:** Soybeans, Beef Cows, Winter Supplementation

**266 Influence of energy supplementation on intake, digestion, ruminal fermentation and microbial efficiency in nursing beef calves.** M.H. Knight\*, J.S. Caton, V. Burke, M.L. Bauer, and G.P. Lardy, *North Dakota State University, Fargo, North Dakota, USA*.

Five Angus crossbred cow-calf pairs ( $653 \pm 35$  kg;  $157 \pm 25$  kg initial BW for cows and calves, respectively) were used to evaluate the influence of supplementation to calves on intake, milk consumption, and digestion. Cow-calf pairs were stratified by calf age and assigned randomly to one of two treatments: control (no supplement) and supplemented. Supplemented calves received 0.9 kg daily of a 49% soy hulls, 44% wheat middlings, 6% molasses, and 1% limestone supplement (DM basis). All calves were given ad libitum access to chopped brome hay (9% CP). Supplementation was initiated on May 1 ( $88 \pm 10.3$  d calf age). Three sampling periods were conducted throughout the study (June 14 to 25, July 5 to 16, and August 9 to 20). Supplement and forage were offered at 0800. Calf total hay and DM intake were not altered by supplementation ( $2.1$  vs  $2.5 \pm 0.4$  kg/d;  $P = 0.56$  and  $1.7$  vs  $1.1 \pm 0.4$  kg/d;  $P = 0.42$ , respectively). Milk consumption was increased by supplementation ( $3.9$  vs  $5.8 \pm 0.04$  kg;  $P = 0.04$ ). Total tract organic matter digestion increased by supplementation ( $64.6$  vs  $72.1$  %;  $P = 0.02$ ) as did true ruminal OM digestion ( $P = 0.10$ ). Ruminal OM digestion also increased ( $P = 0.06$ ) with advancing collection periods, whereas postruminal ( $P = 0.001$ ) OM digestion decreased over time. Supplementation increased microbial efficiency ( $14.4$  vs  $18.3 \pm 0.5$  g;  $P = 0.01$ ). Supplemented calves had higher total VFA ( $78.9$  vs  $96.3 \pm 4.4$  mM;  $P = 0.05$ ) and ammonia ( $2.29$  vs  $5.53 \pm .59$  mM;  $P = 0.02$ ) production. Overall ruminal pH was not affected by treatment and averaged  $6.5 \pm .11$ . Data indicate supplementation of nursing calves increases OM digestion, ruminal VFA concentrations, and microbial efficiency.

**Key Words:** Nursing Calves, Supplementation, Digestion

**267 Influence of cow parity and genetic potential for milk production on forage intake of Brangus females during late gestation.** C.R. Johnson\*<sup>1</sup>, D.L. Lalman<sup>1</sup>, M.A. Brown<sup>2</sup>, and L. Appeddu<sup>2</sup>, <sup>1</sup>Oklahoma Agricultural Experiment Station, <sup>2</sup>USDA-ARS Grazinglands Research Laboratory.

Brangus females ( $n=24$ ) were used in a  $2^2$  factorial arrangement to evaluate the effects of cow parity (multiparous vs first-calf heifers; COW vs HFR) and genetic potential for milk production (MPP; HIGH vs LOW) on forage DMI. Mean sire milk EPD for COW were  $+9.5$  and  $\#9.7$  and were  $+10.8$  and  $\#11.0$ , for HFR, HIGH and LOW groups, respectively. Average initial were  $59015.1$  kg for COW and  $49820.9$  kg HFR and average body condition was  $4.7 \pm 0.1$  (scale 1 to 9). Body condition score and BW were recorded prior to and at the conclusion of the collection period. Animals were housed in a barn equipped with Calan gates to allow for individual forage intake determination. Training and diet adaptation occurred simultaneously for 20 d followed by a 9 d collection period. Cows averaged 57 d and HFR averaged 42 d prepartum upon initiation of the collection period. Bermudagrass hay (4.4% CP and 74.4% NDF; DM basis) was offered at 130% of the previous 2-d average intake. Cottonseed meal was supplemented at 0.2 and 0.3% of initial body weight for cows and heifers, respectively, to ensure adequate degradable protein supply. Hay, orts, and waste were collected daily during the intake determination period. Fecal grab samples were collected at 1000 for 5 d and composited for each animal. Cows consumed 21% more forage DM than HFR ( $10.4$  vs  $8.2 \pm 4$  kg/d;  $P < .01$ ) on an absolute basis. When expressed as a percent of BW, forage DMI did not differ between COW and HFR ( $1.7 \pm 0.8$  % BW;  $P = .5$ ). Genetic potential for milk did not influence ( $P > .6$ ) forage intake, on an absolute or percent of BW basis. Acid detergent insoluble ash was used to estimate DM digestibility. Neither parity group nor milk production potential influenced apparent DM digestibility ( $P > .5$ ) nor fiber digestibility ( $P > .2$ ). During late gestation, Brangus cows and first-calf heifers consume similar amounts of forage DM, when forage DMI is expressed relative to body weight. Additionally, milk production potential did not influence forage DMI during late gestation.

**Key Words:** Forage Intake, Late Gestation, Parity



**268 Influence of cow parity and genetic potential for milk production on forage intake of Brangus females during early lactation.** C.R. Johnson<sup>\*1</sup>, D.L. Lalman<sup>1</sup>, M.A. Brown<sup>2</sup>, and L. Appeddu<sup>2</sup>, <sup>1</sup>Oklahoma Agricultural Experiment Station, <sup>2</sup>USDA-ARS Grazinglands Research Laboratory.

Brangus females (n=24) were used in a randomized complete block design to evaluate the effects of cow parity (multiparous vs first-calf heifers; COW vs HFR) and genetic potential for milk production (MPP; HIGH vs LOW) on forage DMI. Females were selected for MPP based on their sire's EPD for milk. Initial weights were 553 and 44610 kg for COW and HFR. Females were assigned to two periods by postpartum interval, each period averaging 60 d postpartum. Effects in the model included parity group and MPP, and period was considered a random effect. All females were placed in a drylot for a 7-d adaptation to the diet, followed by a 7-d adaptation in the barn and a 9-d collection period. Body condition score and BW were determined at the beginning and end of the collection period. Average BW for the feeding period was determined and used to express forage DMI. Cow-calf pairs were penned individually and bermudagrass hay (5.3% CP and 76.4% NDF; DM basis) was offered ad libitum (130% of previous 2-d average intake). Cottonseed meal was fed at the rate of .4 and .5% of BW for COW and HFR, to ensure adequate protein supply. Hay, orts, and waste were weighed every 2 d. Fecal grab samples were collected at 1000 for 5 d. Milk production was determined on d 7 using a portable milking machine, following a 12-h separation from calves. Acid detergent insoluble ash was used to estimate DM digestibility (DMD). A trend (P=.09) was observed for HIGH to produce 18% more milk than LOW (9.6 vs 7.9.7 kg;). Cows produced 39% more milk than HFR (P<.001). On an absolute basis, COW consumed 16% more forage DM than HFR (P<.001) and HIGH consumed 8% more forage DM (P<.01) than LOW. When forage DMI was expressed as a percent of body weight, parity did not influence forage DMI (2.5.05% BW; P=.2). Yet, HIGH females consumed more forage than LOW (2.6 vs 2.4.05% BW; P=.02). Cows had higher apparent DMD than HFR (51.8 vs 491%; P=.05). When forage DMI is expressed relative to body weight, multiparous cows and first-calf heifers have similar intakes. Females selected for high MPP consumed more forage DM during early lactation than females selected for low MPP.

**Key Words:** Forage Intake, Beef Cows, Lactation

**269 Influence of cow parity and genetic potential for milk production on forage intake of Brangus females during late lactation.** C.R. Johnson<sup>\*1</sup>, D.L. Lalman<sup>1</sup>, M.A. Brown<sup>2</sup>, and L. Appeddu<sup>2</sup>, <sup>1</sup>Oklahoma Agricultural Experiment Station, <sup>2</sup>USDA-ARS Grazinglands Research Laboratory.

Brangus females (n=24) were used in a randomized block design to evaluate the effects of cow parity (multiparous vs first-calf heifers; COW vs HFR) and genetic potential for milk production (MPP; HIGH vs LOW) on forage DMI. Females were selected for MPP based on their sire's EPD for milk. Initial weights were 550 and 46112 kg for COW and HFR. Females were allotted to two periods by postpartum interval, each period averaging 166 d postpartum. Effects in the model included parity group and MPP, and period was considered a random effect. All females were placed in a drylot for a 7-d adaptation to the diet, followed by a 7-d adaptation in the barn and a 9-d intake collection period. Cow-calf pairs were individually penned and bermudagrass hay (5.7% CP and 76.6% NDF; DM basis) was offered ad libitum (130% of previous 2-d average intake). Cottonseed meal was offered .4 (COW) and .45% (HFR) of BW to ensure adequate protein supply. Females were offered hay during 4-h feeding bouts at 0730 and 1800. During feeding, calves were separated and offered ad libitum creep feed and hay. Between feedings, all cows and calves had access to water and trace-mineralized salt. Hay, orts, and waste were collected for each feeding. Fecal samples were collected for 5 d. Milk production was determined on d 7 using a portable milking machine, following a 12-h separation from calves. Acid detergent insoluble ash was used to estimate DM digestibility (DMD). Selection for MPP did not influence milk production (6.7.8kg/d; P>.2) during late lactation. A parity group by MPP interaction was observed for forage DM intake per day (P=.05). Heifers with low MPP consumed 18% less forage DM compared to the mean of LOW and HIGH COW and HIGH HFR. When forage intake was expressed as a percent of body weight, neither parity nor MPP influenced intake (2.2.07% BW; P>.3). A parity group by MPP interaction was observed for DMD (P<.05). The LOW HFR group had 10% lower apparent DMD compared with the average of all others. During late lactation, neither parity group nor selection

of females for divergent MPP influenced forage DMI, expressed as a percentage of BW.

**Key Words:** Forage Intake, Lactation, Beef Cows

**270 Corn silage use in beef cattle growing and finishing diets: hybrid selection and economics.** S.R. Rust<sup>\*</sup>, J.R. Black, and D.D. Buskirk, *Michigan State University.*

Corn silage is a common feed resource for livestock operations in North America. The changing size and structure of beef cattle production units has influenced the usage of this feed resource. Although, use of corn silage has declined due to changes in bunk management and feed inventory control, it remains a significant component of many cattle growing and finishing diets. The pertinent question of cattle producers continues to be what level of corn silage is most profitable. This question is further complicated by the number of corn hybrids available and the diversity of the nutritional traits they possess. Emerging corn silage varieties, including brown midrib and high oil have the potential to impact both hybrid selection and optimum feeding levels. The economics of corn silage hybrid selection is driven by consideration of; 1) relative economic value per kg dry matter, including substitution and performance differences, 2) relative dry matter yield per area, including production and harvesting cost differentials; and 3) harvest scheduling and flexibility. Challenger-defender models may be used to determine both optimal feeding levels and hybrid selection.

**Key Words:** Corn Silage, Hybrid, Economics

**271 Estimating silage energy content and milk yield to rank corn hybrids.** R. D. Shaver<sup>\*</sup>, J. G. Lauer, E. C. Schwab, and J. G. Coors, *University of Wisconsin, Madison.*

We developed a model for estimating the energy value of corn silage and milk yield by dairy cows. The milk yield estimate was evaluated for its potential for ranking corn hybrids. The revised milk Mg-1 and milk ha-1 indices (MILK2000) were evaluated relative to MILK1995 in corn silage hybrid performance trials. A previously published summative energy equation, with crude protein, fat, non-fiber carbohydrate (NFC), and neutral detergent fiber (NDF) fractions and corresponding digestibility coefficients, was adapted for corn silage as follows: the crude protein and fat fractions were not altered, the NFC fraction with constant digestibility was replaced with starch and non-starch NFC fractions, the starch digestibility coefficient was varied in relationship to whole-plant dry matter (DM) content and kernel processing, and the NDF digestibility coefficient based on lignin content was replaced by a 48-hour or maintenance intake in vitro measurement of NDF digestion. For the MILK2000 model, we used this net energy for lactation estimate along with DM intake estimated from NDF content and in vitro measurement of NDF digestion to estimate milk Mg-1of corn silage DM. Corn hybrids with high and low milk Mg-1 were identified and selected on the basis of above average forage yield and either low or high NDF. These high and low NDF hybrids were then included in 61 trials conducted between 1995 and 2000. The frequency with which low NDF hybrids had equivalent or greater milk Mg-1 than high NDF hybrids was 90 to 93%. Maturity at harvest and NDF digestibility both strongly influence the relative hybrid rankings with MILK2000 versus MILK1995. MILK2000 has been found to rank corn hybrids consistently in hybrid performance trials. With advancing maturity, kernel vitreousness (ratio of vitreous to floury endosperm) increases and ruminal starch degradation decreases linearly. Kernel vitreousness is higher and ruminal starch degradation is lower for flint than dent hybrids. Differences in kernel vitreousness may explain differences in starch digestibility for corn hybrids harvested as silage. We hypothesize that future evaluation of corn hybrids for starch and endosperm characteristics and starch degradation may improve the utilization of corn silage by dairy cattle.

**Key Words:** Corn Silage, Dairy Cattle, Digestion

**272 Lactation performance by dairy cows fed wet brewers grains (WBG) or whole linted cottonseed (WCS) to replace forage.** J. L. Firkins<sup>\*</sup>, D. I. Harvatine, J. T. Sylvester, and M. L. Eastridge, *Ohio State University, Columbus.*

Sixty Holstein cows were used to evaluate lactation performance when WBG, WCS, or Easifo WCS (E; 2.5% corn starch to mat linters) were substituted for forage. WBG were added to decrease forage NDF

(FNDF) from 21.1% for the control down to 19.1, 17.0, and 15.0%. The WCS and E diets both had 15% FNDF. Soybean hulls and corn were balanced to decrease nonfiber carbohydrates (NFC) with decreasing FNDF, with feed analyses averaging 41.3, 38.8, 35.1, 33.8, 33.1, and 36.0%, respectively. Cows were fed the control TMR during wk 8 and 9 of lactation. Then, biweekly BST injection commenced, and they were blocked to either remain on the control or be switched to one of the five other TMR diets from wk 10 to 25 of lactation. Cows were milked twice daily, and four consecutive milkings per week were sampled for fat and crude protein analyses. Feed samples were collected weekly and composited per month prior to standard nutrient analyses (DM, OM, CP, NDF, fatty acids, lignin, and CP contamination of NDF and ADF). Data were analyzed using repeated measures (Proc Mixed; cow was a random effect) for a randomized complete block design, and single df contrasts were performed. No treatment  $\times$  time interactions ( $P > 0.10$ ) were detected. No differences ( $P > 0.10$ ) in any production measurement was determined except for a lower ( $P < 0.01$ ) concentration of milk fat for E vs WCS. The weighted mean of nutrient analyses plus the average performance data and body condition score for the treatment period were entered into the NRC (2001) software for each cow. The NRC accounted for an average of 99% of the  $NE_L$  intake as energy output; intake of discounted  $NE_L$  averaged 3.8% of maintenance. No treatment differences were detected ( $P > 0.10$ ). However, when analyzed for individual cows, the energy model resulted in nonrandom errors for prediction of BW change. Results are interpreted to support the NRC model for energy usage by groups of cattle and its guidelines for FNDF and NFC. The E cottonseed was interpreted to be nearly as effective as WCS.

**Key Words:** Wet Brewers Grains, Whole Linted Cottonseed, Dairy Cows

**273 Effect of alfalfa silage, corn silage and levels of crude protein on ruminal pH and ammonia concentration over a 24 hour period in lactating dairy cows.** K.L. Karg\*, L. Perdureau, and M.A. Wattiaux, *University of Wisconsin-Madison*.

Twelve multiparous ruminally cannulated Holstein cows were used to evaluate the effect of forage source (alfalfa silage (AS) or corn silage (CS)) and CP level (16.5% (LP) or 17.9% (HP)) on ruminal pH and ammonia concentration. Cows were blocked by calving date and assigned to dietary treatments arranged in a 2  $\times$  2 factorial. Diets were 55% forage (DM basis; 14% CS and 41% AS or 14% AS and 41% CS). Diets provided RDP balance of -6 g/d (LP diets) or +132 g/d (HP diets) according to NRC 2001. Cows were fed a TMR *ad libitum* once a day at 8:00 am. At 60 $\pm$ 3 DIM ruminal fluid was collected for pH and ammonia concentration measurements every two h for a 24 h period. Data were analyzed with the proc MIXED procedure of SAS and differences between forage sources and protein levels were tested with orthogonal contrasts. There were no statistical differences in ruminal pH among dietary treatments, however changes over time were significant. The 24 h pH fluctuation was greater on CS diets compared to AS diets. From approximately 4 to 14 h after feeding, pH levels tended to be lower for CS than AS diets. From 16 h until 4 h after feeding, the converse was true and the differences widened to become significant two h after feeding (CS=6.98 vs. AS=6.54;  $P<0.05$ ). Peak pH levels for AS (6.71) and CS (6.99) occurred at feeding and tended to be different ( $P=0.07$ ); nadir occurred at 12 h after feeding AS (6.14) and CS (5.95) and were not statistically different. There were no statistical differences in ruminal ammonia concentration among dietary treatments, however changes over time were significant. From 4 to 8 h after feeding, ruminal ammonia concentrations were higher ( $P<0.05$ ) on HP diets than LP diets. Ammonia concentration peaked higher (22.96 mg/dl) and later (6 h) after feeding and tended to remain higher for the HP diets compared to LP diets which peaked 2 hours after feeding at 17.25 mg/dl. Ruminal environment was more stable on the LP AS based diet, while the HP CS based diet exhibited larger fluctuations in pH and ruminal ammonia concentration.

**Key Words:** Forage, Diurnal Variation, Rumen

**274 Evaluation of graded levels of fish oil and extruded soybeans in diets of lactating dairy cows.** L. A. Whitlock\*, D. J. Schingoethe, A. R. Hippen, K. F. Kalscheur, and A. A. Abu-Ghazaleh, *South Dakota State University, Brookings*.

Inclusion of fish oil into the diets of lactating dairy cows has been shown to be one of the most effective ways of increasing the concentration of transvaccenic acid (TVA) and cis-9,trans-11 conjugated linoleic acid

(CLA) in the milk of dairy cows. The objective of this study was to determine the minimum level of dietary fish oil necessary to increase milk TVA and CLA concentrations. Eight multiparous Holstein (189 DIM) and four multiparous Brown Swiss (126 DIM) cows were assigned randomly to four treatments in a replicated 4  $\times$  4 Latin square with 4 wk periods. The four treatments consisted of: 1) control; 2) control diet with 0.33% (DM basis) added fat from menhaden fish oil, and 1.67% added fat from extruded soybeans; 3) control diet with 0.67% added fat from fish oil and 1.33% added fat from extruded soybeans; and 4) control diet with 1% added fat from fish oil and 1% added fat from extruded soybeans. Milk production (21.9, 23.4, 22.9, and 23.9 for cows fed diets 1 to 4, respectively) was greater ( $P < 0.01$ ) for cows that received supplemental fats compared with control, but was not different ( $P > 0.10$ ) among cows fed supplemental fat. Milk fat (4.42, 3.81, 3.80, and 4.03%) and protein (3.71, 3.58, 3.54, and 3.55%) concentrations were greater ( $P < 0.01$ ) for cows fed the control diet. Milk fat ( $P = 0.07$ ) and protein ( $P = 0.49$ ) concentrations did not differ among cows receiving supplemental fat. Milk from cows fed the three diets containing supplemental fat contained greater ( $P < 0.01$ ) concentrations of TVA (1.12, 2.47, 2.13, and 2.63 g/100g FA) and CLA (0.55, 1.17, 1.02, and 1.19 g/100g FA) than did milk from cows fed the control diet. Concentrations of TVA ( $P = 0.42$ ) and CLA ( $P = 0.79$ ) were similar for cows fed the diets 2 and 4. These data showed that optimal TVA and CLA concentrations were achieved at the lowest level of fish oil inclusion.

**Key Words:** Conjugated Linoleic Acid, Trans Fatty Acid, Fish Oil

**275 Chronic glucagon administration and lipoprotein composition in periparturient dairy cows.** B. N. Ametaj\*, G. Bobe, J. W. Young, and D. C. Beitz, *Iowa State University, Ames, IA*.

The objective of this research was to study the effects of subcutaneous injections of glucagon on composition of plasma lipoproteins in postpartum dairy cows. One group of cows ( $n=8$ ) served as control, the second group ( $n=8$ ) was injected with 60 ml of saline, whereas two other groups ( $n=8$ ) were injected subcutaneously with 2.5 and 5 mg of glucagon (3xd), respectively, for 2 wk starting at 8 d after parturition. Blood was obtained from jugular vein at 4 d before parturition as well as on days 3, 8, 12, 14, 22, 27, 36, and 43 after parturition. Plasma VLDL, LDL, HDL and very high-density lipoprotein (VHDL) fractions were separated by ultracentrifugal flotation and the amounts of triacylglycerols (TG), total cholesterol (TC), and phospholipids (PL) associated with each fraction were determined. Concentrations of TG in VLDL and LDL fractions were at 45 and 65 mg/dl before parturition, declined at 12 and 30 mg/dl immediately after parturition and remained at these levels during 6 wk postpartum. Total cholesterol was low in LDL, HDL, and VHDL (15, 45, and 5 mg/dl, respectively) before calving and reached zenith at 6 wk after calving (40, 77, and 10 mg/dl, respectively). Concentrations of PL in HDL and VHDL fractions increased from precalving values of 50 and 4 mg/dl to 75 and 8.5 mg/dl, respectively, at 6 wk after parturition. Treatment with 7.5 and 15 mg of glucagon/d for 2 wk had no effect on concentrations of TG, TC, and PL in lipoprotein fractions of periparturient dairy cows.

**Key Words:** Glucagon, Lipoproteins, Dairy Cows

**276 Effect of protein level in prepartum diets on metabolism and performance of dairy cows.** A.F. Park\*, J.E. Shirley, E.C. Titgemeyer, R.C. Cochran, T.A. Wickersham, J.M. DeFraen, E.E. Ferdinand, A.K. Hammond, and D.G. Schmidt, *Kansas State University*.

Fifteen ruminally fistulated, crossbred steers (BW=190  $\pm$  13 kg) were utilized in a randomized block design to validate the use of selected markers for estimating digestibility of typical dairy cattle diets. Steers were blocked by initial body weight and assigned to one of four dairy diets: late lactation (1.73 Mcal/kg  $NE_L$ , 18.7% CP), far-off (1.46 Mcal/kg  $NE_L$ , 11.5% CP), close-up (1.56 Mcal/kg  $NE_L$ , 15.6% CP), and an early lactation (1.70 Mcal/kg  $NE_L$ , 18.4% CP) diet. Dry matter intake was set at 2% of BW. Trial length was 21 d consisting of a 14-d adaptation period followed by a 7-d total fecal collection. Digestibility markers evaluated were indigestible acid detergent fiber (IADF), acid detergent insoluble ash (ADIA), and titanium dioxide ( $TiO_2$ ). Samples of feed, orts, and feces were analyzed for IADF (144 hr incubation in ruminal fluid followed by ADF determination conducted using standard procedures or with ANKOM adaptations), ADIA (ADF determined in

berzelius beakers or ANKOM apparatus followed by ashing for 8 hrs. at 450° C), and TiO<sub>2</sub> (determined calorimetrically; 5 g fed daily via cannula). For both approaches, IADF was measured without acid/pepsin, with acid/pepsin before incubation, or with acid/pepsin after incubation. The ANKOM techniques for IADF without acid/pepsin and with acid/pepsin before incubation yielded fecal recoveries that were less ( $P < 0.01$ ) than 100% for all diets. The standard technique for IADF without acid/pepsin yielded fecal recoveries that were not different from 100% for the far-off, close-up, and early lactation diets. Fecal recoveries of ADIA were variable among diets. Fecal recoveries of TiO<sub>2</sub> were greater ( $P < 0.01$ ) than 100% for late lactation, far-off, and early lactation diets. In conclusion, IADF assessed via standard procedures without inclusion of an acid/pepsin incubation step appeared to yield relatively quantitative marker recovery for a range of typical dairy cattle diets.

**Key Words:** Digestibility, Internal Marker, Dairy

**277 Amplification of 18S rDNA sequences from protozoal-enriched rumen samples to study ruminal protozoal ecology.** S. K. R. Karnati\*, J. T. Sylvester, Z. Yu, B. A. Dehority, and J. L. Firkins, *The Ohio State University*.

Our current understanding of the role of rumen ciliate protozoa has suffered because of the difficulty associated with their cultivation and the expense and difficulties of manipulating protozoal populations in vivo. A PCR-cloning-sequencing approach was used to evaluate a protozoal-specific primer used with a eukaryotic-specific reverse primer to amplify the 18S rDNA from genomic DNA extracted from samples of protozoa from rumen fluid collected from two cows fed either a 50:50 forage:grain diet or all alfalfa hay. After incubation for 1 h at 39°C, sedimented protozoa were extracted and washed. An aliquot was fixed in 50% formalin and used for the counting and generic distribution of protozoa compared with the original ruminal sample. DNA was extracted using the CTAB method and a 1360-bp fragment of the 18S rRNA gene was amplified using PCR. One SSU rDNA clone library was constructed for each sample, and clones were randomly chosen and sequenced. All the DNA sequences (23 total) were 93-99% identical to sequences from rumen ciliates already deposited in databases, indicating that the primer is highly specific. Comparison of counts from the enriched samples vs original ruminal samples showed that there was a selective enrichment for *Dasytricha* and *Isotricha* at the expense of *Entodinium* from the alfalfa-fed cow. The use of a combination of filters to concentrate protozoa rather than through sedimentation has reduced sampling bias in preliminary experiments. For the cow fed only alfalfa hay, the protozoa-specific forward primer biased completely against *Entodinium* spp. due to a single base mismatch in the primer used. Use of a degenerate primer (original combined with a modified primer corrected for the base mismatch) is being evaluated to reduce this apparent PCR bias.

**Key Words:** Rumen Protozoal Ecology, 18S rDNA Analysis

**278 Effect of feeding time and sprinkling on performance and body temperature of steers.** M.S. Davis\* and T.L. Mader, *University of Nebraska*.

This study was conducted to examine possible strategies to reduce heat stress of feedlot cattle fed and finished in July and August. One hundred, ninety-two *Bos taurus* steers ( $BW = 424 \pm 26$  kg) were used to evaluate feeding time (0800 [AM] vs 1400 [PM]) and sprinkling (no sprinkling [DRY] vs sprinkling mounds in pens [WET]) in a 2 x 2 factorial arrangement of treatments (TRT). Steers were randomly assigned to 24 pens (8 hd/pen). Feed amount was adjusted daily so that all bunks were clean at 0800, while sprinkling was done via overhead water sprinklers on days when predicted temperature-humidity index was  $\geq 77$ . Feed and water intakes were recorded daily, while BW was determined on days 0, 21, 56 and 83 (termination of trial). From d 0 to 20 (June 8 to 28) all pens were managed similarly with no sprinkling and feed delivered at 0800. Tympanic temperatures (TT) of steers (6 hd/TRT) and climatic conditions of pens were obtained on d 29 to 34 and 56 to 63. Body weight and DMI were not affected by TRT ( $P \geq .10$ ). Average daily gain and feed efficiency from d 57 to 83 were improved 13% ( $P = .08$ ) and 15% ( $P = .06$ ), respectively by sprinkling ( $1.48$  vs  $1.68 \pm .08$  kg/d and  $.148$  vs  $.170 \pm .160$ ). Water intake was increased 13% from d 22 to 56 in AM/DRY vs PM/WET steers (feeding time x sprinkling interaction,  $P \leq .05$ ) with AM/WET and PM/DRY being intermediate. Water intake of AM/DRY steers averaged 13% and 11% higher ( $P \leq .05$ ) than all other steers on d 57 to 83 and 22 to 83, respectively. On

d 30 to 33, of AM/DRY steers had higher TT ( $P \leq .06$ ). On d 62 to 63 TT of PM steers were higher ( $P \leq .05$ ) than AM steers from 1600 to 1900. Wetting mounds reduced soil temperatures ( $P \leq .05$ ) at all times, and temperatures at .15 and .76 m above the mound ( $P \leq .05$ ) between 1000 and 1730. Adjusting feeding time and sprinkling cattle can alter body temperature. Performance data suggest allowing cattle access to sprinklers during hot days improves performance. Effects of AM vs PM feeding were not observed, although interactions were apparent.

**Key Words:** Feeding Time, Sprinkling, Tympanic Temperature

**279 Type of corn bran and corn processing method in beef finishing diets.** C. N. Macken\*<sup>1</sup>, T. J. Klopfenstein<sup>1</sup>, G. E. Erickson<sup>1</sup>, and R. A. Stock<sup>2</sup>, <sup>1</sup>University of Nebraska-Lincoln, <sup>2</sup>Cargill Inc., Blair, NE.

A finishing trial was conducted to determine the effects of corn bran type in either dry-rolled or steam-flaked corn based diets. Three hundred and forty crossbred yearling steers (354 kg) were stratified by weight and randomly assigned to 1 of 40 pens (10 steers/pen in replication 1 and 8 steers/pen in replications 2, 3 and 4). Treatments were assigned based on a 2 # 4 + 2 factorial design with factors of grain source and bran type. Grain sources were dry-rolled (DRC) or steam-flaked (SFC) corn. Bran types were dry (90% DM), wet (40% DM), dry and rehydrated to either 40% or 60% moisture. Bran was fed at 30% of the dietary DM, replacing either DRC or SFC. Two control diets were fed with no added bran. All diets contained corn steep liquor with distillers solubles at 10% of the diet DM. Sorghum silage was included in all diets, including step-up diets, at 3.5% DM. Alfalfa hay was included at 3.5% DM in the final finishing diet. Step-up diets contained 41.5%, 31.5%, 21.5% and 11.5% DM alfalfa hay replacing the corn in each treatment diet. Bran type had no effect on performance or carcass characteristics. Dry matter intake was higher ( $11.4$  vs.  $10.7$  kg/d;  $P < 0.01$ ) for steers fed bran compared to no bran and for steers fed DRC compared to SFC ( $11.6$  vs.  $11.0$  kg/d;  $P < 0.01$ ). Interactions occurred ( $P < 0.01$ ) between grain source and bran inclusion for ADG and feed efficiency. Daily gain for SFC diet without bran was higher ( $P < 0.01$ ) than SFC diets with bran while DRC diets with or without bran were similar. Daily gain was 15.2% higher ( $1.95$  vs.  $1.69$  kg/d;  $P < 0.01$ ) for steers fed SFC without bran compared to DRC without bran. Feed efficiency was 16.9% higher ( $0.183$  vs.  $0.157$ ;  $P < 0.01$ ) for steers fed SFC without bran compared to DRC without bran. In DRC and SFC diets, feeding bran decreased feed efficiency by 5.2% and 13.8%, respectively. Bran type had no effect on finishing steer performance in either dry-rolled or steam-flaked corn based finishing diets.

**Key Words:** Beef Cattle, Corn Bran, Corn Processing

**280 Effects of growth promotants on feedlot heifers fed in winter vs. summer.** W.M. Kreikemeier\* and T.L. Mader, *University of Nebraska-Lincoln*.

Two 104 day finishing trials were conducted utilizing Angus x crossbred heifers (270 head/trial). Trials were conducted from December, 1999 through March, 2000 (winter) and from June, 2001 through September, 2001 (summer). Treatments (TRT) were identical for each trial and included 1) no implant or MGA (CONT); 2) estrogenic implant (E) 3) trenbolone acetate implant (TBA) 4) E+TBA 5) MGA fed (MGA); 6) E+TBA+MGA. Each TRT consisted of five pens/trt and nine head/pen in each trial. A common dressing percent (63%) was used to calculate final weight (FWT). Initial weights (mean=384 kg; SE=.57) were the same for each trial. There were no ( $P \geq .20$ ) TRT x season interactions for FWT, ADG or GF. Heifers receiving a growth promotant were 11.6 kg (SE=4.08) heavier and gained .108 kg/d (SE=.04) more ( $P \leq .05$ ) than CONT heifers. Average daily gains were 1.25, 1.33, 1.31, 1.38, 1.34 and 1.42 (SE=.036) for TRT 1 through 6, respectively. Heifers receiving E+TBA (TRT 4 and 6) gained .09 kg/day (SE=.032) more ( $P \leq .05$ ) than heifers not receiving E+TBA. Gain:feed ratios were .121, .129, .128, .131, .132 and .136 for TRT 1 through 6, respectively. Heifers receiving E+TBA with and without MGA and MGA alone (TRT 4, 5 and 6) had converted .007 (SE=.003) better than CONT, E and TBA heifers. There was a tendency to have TRT x season interaction ( $P=.13$ ) for DMI (Table). Heifers fed MGA and implanted with E+TBA tended to have enhanced DMI in the summer and suppressed DMI in the winter. Implanting tended to produce relatively similar performance in summer vs. winter. However, the effects of feeding MGA when combined with

E+TBA differed among seasons. Feeding MGA alone tended to decrease DMI regardless of season.

Table 1. Effects of treatment x season interaction on DMI (SE=.18)

	1	2	3	4	5	6
Summer	9.11 <sup>a</sup>	9.23 <sup>a</sup>	9.15 <sup>a</sup>	9.39 <sup>ab</sup>	9.14 <sup>a</sup>	9.65 <sup>b</sup>
Winter	11.57 <sup>ab</sup>	11.63 <sup>ab</sup>	11.54 <sup>ab</sup>	11.69 <sup>b</sup>	11.16 <sup>a</sup>	11.24 <sup>ab</sup>

<sup>ab</sup> means are different  $P \leq .05$

**Key Words:** Growth Promotants, Feedlot Heifers, Season

## 281 Effects of supplemental energy source on utilization of corn silage by beef steers. C. M. Howlett\*, E. S. Vanzant, B. G. Fieser, and K. B. Combs, <sup>1</sup>University of Kentucky.

Six crossbred steers (387 kg) were used in a 6 x 6 Latin square design to evaluate supplemental energy source effects on utilization of corn silage diets. Treatments consisted of six corn silage (CS; CP=9.1%, TDN=67%) diets. Treatments were 1) soybean meal (SBM) at 10% DMI; 2) corn and soybean meal (CSBM) at 56% DMI; 3) whole linted cottonseed (COT) at 15% DMI; 4) whole raw soybeans (SB) at 15% DMI (SB1); 5) SB at 25% DMI (SB2); or 6) pelleted soybean hulls (SH) at 30% DMI. CS comprised 88% of DMI in diet 1 and 42% of DMI in diets 3 through 6. COT, SB1, SB2, and SH replaced a portion of the corn and soybean meal. Diets were formulated to be isonitrogenous (13.7% CP) except for SB2 (17% CP) and were fed twice daily at 1.8 x NEm. DMD was lowest ( $P < .10$ ) for SBM (67.5%), intermediate for oilseed supplementation (COT, 73.3%; SB1, 75.6%; SB2, 73.9%), and greatest for CSBM (79.6%) and SH (78.3%). Ruminal ammonia concentrations were greater ( $P < .10$ ) for SB2 (11.3 mM) than for COT (6.2 mM), SBM (6.9 mM), CSBM (7.1 mM), SB1 (7.0 mM), and SH (6.8 mM). Ruminal pH was lower ( $P < .10$ ) for CSBM (6.23) and SH (6.27) than for COT (6.46), SBM (6.51), SB1 (6.49), and SB2 (6.45). Molar proportions of ruminal acetate were lowest ( $P < .10$ ) for SB2 (61.4%), intermediate for SB1 (63.0%), COT (64.0%), and CSBM (64.0%), and greatest for SBM (67.6%), and SH (67.1%). Propionate proportions for SBM (16.8%), CSBM (17.3%), and SH (16.5%) were lower ( $P < .10$ ) than for SB1 (20.0%), COT (20.6%), and SB2 (21.6%). Acetate:propionate ratios were lowest ( $P < .10$ ) for SB2 (2.88), SB1 (3.17), and COT (3.19), intermediate for SBM (4.17) and CSBM (3.76), and greatest for SH (4.36). Molar proportions of butyrate were lowest ( $P < .10$ ) for SB2 (10.9%), SB1 (11.4%) and SBM (11.5%), intermediate for SH (12.9%), and greatest for CSBM (14.4%). Ruminal proportions of isobutyrate, isovalerate, and valerate were generally increased when oilseeds were supplemented. Inclusion of oil-rich supplements decreased ruminal VFA concentrations, reduced acetate:propionate ratio and decreased DMD. Supplementation with whole soybeans at 25% of DMI increased ruminal ammonia concentration.

**Key Words:** Oil, Rumen, Fermentation

## 282 Influence of fish oil addition to finishing diets on carcass characteristics, immune function, and growth performance of cattle. T. J. Wistuba\*, E. B. Kegley, and J. K. Apple, University of Arkansas, Fayetteville, Ar/USA.

Inclusion of fish oil, a source of omega-3 fatty acids, in ruminant diets may fortify the fatty acid composition of meats and modulate the immune system. Therefore, a 70-d study using 16 crossbred steers (441 ± 31.7 kg initial BW; 4 calves/pen; 2 pens/ dietary treatment) consuming a high concentrate ration was conducted. Dietary treatments consisted of: 1) control (75% corn, 11% soybean meal, and 10% cottonseed hull based diet); and 2) the control diet with 3% fish oil replacing a portion of the corn. Steers were weighed on consecutive days at d 0 and 70 to start and finish the trial and interim weights were taken on d 28 and 56. On d 63, all calves were bled by jugular venipuncture for flow cytometric analysis to determine the populations of leukocytes. Calves were stratified by treatment and harvested on d 71 and 72. Fish oil supplementation decreased daily feed intake (13.97 vs. 11.49 kg,  $P < 0.01$ ); conversely it had no effect on ADG or G:F ( $P > 0.05$ ). Fish oil did not alter color of longissimus muscle (LM), LM area, yield grade, dressing percentage, marbling, quality grade, or fat thickness. Though, fish oil supplementation decreased hot carcass weight (329 vs. 303 kg,  $P < 0.05$ ), and tended to decrease percentage internal fat (2.28 vs. 1.94,  $P = 0.12$ ). Fish oil supplementation increased the number of receptors expressed on lymphocytes ( $P < 0.01$ ), and tended to increase the ratio

of the number of receptors on T lymphocytes compared to the number of receptors on B lymphocytes ( $P = 0.06$ ). In summary, supplementation with fish oil decreased growth performance and subsequent hot carcass weights and had varying results on immune parameters. Nevertheless, no negative results were elucidated for the effects of fish oil supplementation on carcass quality. Further work is being conducted to determine the effect of supplementing fish oil on the fatty acid composition of the carcass.

**Key Words:** Fish Oil, Finishing Cattle, Carcass Characteristics

## 283 Ruminal fermentation characteristics and duodenal amino acid flows in beef cattle fed varying levels of bloodmeal. J.W. Lehmkuhler\*,<sup>1</sup> E.E.D. Felton<sup>2</sup>, C.J. Fu<sup>2</sup>, and M.S. Kerley<sup>2</sup>, <sup>1</sup>University of Wisconsin, <sup>2</sup>University of Missouri.

Five crossbred beef steers with rumen fistulas and duodenal #Y#-type cannulas were fed a high grain, feedlot-type diet with increasing levels of bloodmeal (BM). Levels tested included 0%, 3%, 6%, 9%, and 12% of the diet DM. Rumen fermentation characteristics and amino acid flows to the small intestine were examined. Dry matter intake was not affected by the level of BM included and averaged 2.4% of live body weight (BW). Organic matter digestibility in the rumen and total tract did not differ across dietary treatments. Nitrogen intake and flow to the duodenum increased linearly ( $P < .05$ ) with level of BM. The quantity (g/d) of total and nonmicrobial N increased linearly ( $P < .05$ ). When expressed as the percentage of duodenal N flow, microbial and nonmicrobial N contribution were not different ( $P > .10$ ). True ruminal N digestibility increased linearly ( $P < .01$ ) with level of BM addition resulting in a linear ( $P < .10$ ) decrease in the proportion of intake N corrected for microbial N arriving at the small intestine or escape N. Microbial efficiency responded quadratically ( $P = .08$ ) to level of BM. Total VFA production increased linearly ( $P = .05$ ) to BM. Total branched-chain VFA#s increased linearly ( $P < .05$ ) as BM level was increased. Duodenal amino acid flow increased linearly ( $P < .05$ ) with BM addition while most plasma amino acids did not respond to BM inclusion. These data illustrated that the rumen degradability of the BM protein was dependent upon dietary inclusion level.

**Key Words:** By-pass protein, Feedlot, Amino acid

## 284 Effect of an inoculant extender on the pH decline of liquid applied silage inoculant and terminal silage pH. J. S. White\*,<sup>1</sup> K. Katzung<sup>2</sup>, and N. Prescher<sup>3</sup>, <sup>1</sup>Silage Solutions, Sioux Center, IA, <sup>2</sup>Northland Farm Systems, Owatonna, MN, <sup>3</sup>AgScience, Sioux Falls, SD.

Silage managers question the shelf life of hydrated, liquid applied silage inoculant. The objectives of this study were to determine the influence of an inoculant extender on the pH decline of liquid applied inoculant, and determine if subsequent silage pH was affected by treatment with extended inoculant.

The pH of liquid applied silage inoculant replicates (n=4), without or with the addition of an extender was monitored from 0 to 103 hours after mixing. Multiple regression analysis was used to determine the effect of time after mixing (Hour) and the use of extender on the pH of the inoculant.

The R square was .859. Time after mixing and whether or not an extender was used explained most of the observed variation in inoculant pH.

Whole plant, soft dough barley and wheat were treated with: 1) Control, (no inoculant), 2) Fresh inoculant (6 hours old) 3) Old inoculant, (55 hours old) 4) Extended inoculant, Old inoculant, with extender added at mixing. Each treatment had four replicates. The 19 liter plastic silos were opened 42 days after ensiling, and the silage pH determined.

One way ANOVA indicated that significant differences,  $P < .001$ , existed among the treatments for both crops. Treatment means were compared using the LSD test. For barley the  $P = .05$  LSD was .0346. The treatment means were: Control 4.11<sup>a</sup>, Fresh inoculant 3.99<sup>b</sup>, Old inoculant 4.13<sup>a</sup>, Extended inoculant 3.96<sup>b</sup>. For wheat the  $P = .05$  was .065. The treatment means were: Control 4.18<sup>a</sup>, Fresh inoculant 3.92<sup>b</sup>, Old inoculant 4.15<sup>a</sup>, Extended inoculant 3.95<sup>b</sup>.

In this study the use of an extender significantly affected the pH decline of liquid applied silage inoculant. Silages treated with extended inoculant had pH values similar to silages treated with fresh inoculant.

Variable	Coefficient	SEM	P<
pH intercept	5.34	.137	.001
Hour	-.011	.002	.001
Extender	1.76	.081	.001

**Key Words:** Silage, Inoculant Extender, pH

**285 Effect of cutting height and genetics on intake and digestibility of corn silage.** L. R. Kennington<sup>\*1</sup>, C. W. Hunt<sup>1</sup>, J. I. Szasz<sup>1</sup>, A. V. Grove<sup>1</sup>, and W. Kezar<sup>2</sup>, <sup>1</sup>University of Idaho, Moscow, <sup>2</sup>Pioneer Hi-Bred International, Johnston, Iowa.

Four minimally cannulated beef heifers were used in a 4 x 4 Latin square experiment. Main effects and interactions of hybrid (Pioneer **3335** and **3223**) and cutting height (**LO**, 20 cm and **HI**, 61 cm) were evaluated. Corn silage treatments were stored in manually packed 1.0- x 1.25- x 1.5-m boxes lined with plastic bags. Dietary treatments consisted of 40% alfalfa and 60% corn silage (DM basis). Chromic oxide was fed (10 g/hd/d) beginning 7 d before fecal sample collection for use as an external digestibility marker. The hybrids were of similar maturity at time of harvest (60% milkline), however 3335 treatments were analyzed to have greater starch and less NDF than 3223 treatments (average 37.8 versus 33.7% and 34.8 versus 38.6%, respectively). The LO treatments averaged 3.1 percentage units higher in NDF and 3.45 percentage units lower in starch content than the HI treatments. Intake of DM was greater for 3335-HI than 3335-LO; however, DMI was greater for 3223-LO than 3223-HI (hybrid x cutting height,  $P < 0.05$ ). Starch intake was greater ( $P < 0.05$ ) for heifers fed HI than LO and 3335 than 3223 dietary treatments. Conversely, NDF intake was greater ( $P < 0.05$ ) for heifers fed 3223 than 3335 and LO than HI dietary treatments. Digestibility of DM, starch, and NDF was greater ( $P < 0.05$ ) for heifers fed 3223 diets than 3335 diets. Digestibility differences were not observed ( $P > 0.10$ ) for cutting height treatments. Rate of *in situ* DM, NDF, and starch degradability was not affected ( $P > 0.10$ ) by hybrid or cutting height; however, DM degradability was greater ( $P < 0.05$ ) for HI than LO corn silage substrates at 8, 16, and 24 h of incubation. Degradability of NDF was greater ( $P < 0.05$ ) for 3223 than 3335 substrates at 24, 36, and 48 h and tended ( $P = 0.07$ ) to be greater at 96 h of incubation. Corn silage from 3223 was more digestible despite having a greater NDF content, suggesting fiber may not be an accurate measure of corn silage quality. While cutting height impacted chemical composition, we observed genetics to have a greater impact on corn silage quality.

**Key Words:** Forage Quality, Fiber, Starch

**286 Degradability of crude protein and nonstructural carbohydrate in selected feeds and grain mixes.** D.P. Casper<sup>\*1,2</sup>, M.J. Brouk<sup>3</sup>, and D.J. Schingoethe<sup>3</sup>, <sup>1</sup>Agri-King, Inc., Fulton, IL, <sup>2</sup>USDA-ARS, Beltsville, MD, <sup>3</sup>South Dakota State University, Brookings.

Estimates of degradability of crude protein (CP) and nonstructural carbohydrate (NSC) of feeds are required to synchronize CP and NSC for optimum ruminal fermentation. It is unknown if these estimates are different due to associative effects of individual ingredients when combined into grain mixes. Samples of corn (C), barley (B), soybean meal (S), extruded S (E), grain mixes (C-S, C-E, B-S, B-E), corn silage, and alfalfa hay were obtained from previous CP and NSC studies. Two rumen cannulated dairy cows were used with two replicates each of duplicate nylon bags inserted in reverse sequence for time points of 0, 1, 2, 3, 4, 6, 8, 10, 12, 18, 24, 36, and 48 hr. Data were fitted to the nonlinear equation of  $D=R+(P-R)*(1-e^{-ct})$ . Regression coefficients for NSC source (C vs B), CP source (S vs E), grain mixes, and forages were subjected to analysis of variance with cow and rep as sources of variation. Degradation rates were greater for B than for C in DM (.051 and .097%/hr for C and B, respectively,  $P < .01$ ), CP (.033 and .104%/hr,  $P < .06$ ), and NSC (.071 and .105%/hr,  $P < .07$ ). Degradation rates were lower for E than for S in DM (.073 and .050%/hr for S and E, respectively,  $P < .01$ ) and CP (.061 and .034%/hr,  $P < .01$ ). Degradation rates of DM (.044, .043, .067, .080%/hr for C-S, C-E, B-S, and B-E, respectively) were greater for B grain mixes than C grain mixes. Degradation rates of CP (.042, .037, .057, .048%/hr) were greater ( $P < .05$ ) for the B-S grain mix than other mixes. Degradation rates of NSC (.049, .048, .080, and .107%/hr) were greater ( $P < .05$ ) for the B grain mixes than the C grain mixes. Degradation rates of DM (.024 and .048%/hr for corn silage and alfalfa hay, respectively) and CP (.003 and .044%/hr) were greater ( $P < .01$ ) for

alfalfa hay, but NSC degradability (.158 and .051%/hr) was greater for corn silage. The degradation rates of CP and NSC in the grain mixes represented the combined percentages of the degradability estimates of CP and NSC from individual ingredients.

**Key Words:** Nonstructural Carbohydrates, Crude Protein, Degradation Rates

**287 The effects of volatile fatty acid on acid-resistance of cattle fecal *E. coli* and *E. coli* O157:H7.** C. J. Fu<sup>\*1</sup>, J. H. Porter<sup>1</sup>, E. E. D. Felton<sup>1</sup>, J. W. Lehmkuhler<sup>2</sup>, and M. S. Kerley<sup>1</sup>, <sup>1</sup>University of Missouri-Columbia, <sup>2</sup>University of Wisconsin-Madison.

Hungate tube pure culture incubations were used to determine the effect of volatile fatty acid concentration (VFA: acetate, propionate, and butyrate) on extreme acid-resistance of cattle fecal *E. coli* and *E. coli* O157:H7. The fecal *E. coli* samples were from a continuous culture study designed for determining the effects of pH on extreme acid-resistance of fecal *E. coli* which was presented at the ASAS-ADSA-AMSA-PSA joint meeting of 2001 (abstract #: 322). The *E. coli* O157:H7 (505B strain) was kindly donated by another lab at the University of Missouri-Columbia. The acetate, propionate, and butyrate concentrations tested were 0-25, 0-20, and 0-20 mM, respectively. The media used for the pure culture incubations was tryptic soy broth without dextrose (pH: 7.3 ± 0.2) and the pure VFA was used to adjust their concentration in the media. Tubes were inoculated with fecal *E. coli* and *E. coli* O157:H7 and then sampled after 24 h of incubation. The acid shock media consisted of 10 grams tryptone and 5 grams yeast extract per liter and the pH was adjusted to 2.0 with 6N HCl. Viable *E. coli* were enumerated by the multi-tube fermentation method (AOAC, 1998) using lauryl sulfate trypticase broth. The viability after extreme acid shock (1 h for fecal *E. coli* and 4 h for *E. coli* O157:H7) of fecal *E. coli* and *E. coli* O157:H7 showed quadric responses ( $P < 0.05$ ) as acetate and butyrate level increased with maximum acid-resistance at 20 and 12 mM, respectively. As the propionate concentration increased, the extreme acid-resistance showed trend of quadric responses ( $P < 0.15$ ) with maximum acid-resistance at 12 and 4 mM for fecal *E. coli* and *E. coli* O157:H7, respectively. This study indicated that the extreme acid-resistance of *E. coli* could be induced by all three VFAs even though the environmental pH was near neutral; and further more, the acid-resistance might depend on the concentration of the VFAs. This study supported and enhanced the previous hypotheses that culture VFA levels affect acid-resistance of *E. coli*.

**Key Words:** *E. coli*/*E. coli* O157:H7, VFA, Acid-resistance

**288 Inhibition of methanogenesis in ruminal cultures by p-aminobenzoate (pABA) analogs.** B. A. DeMontigny<sup>\*</sup>, R. Dumitru, S. Schroeder, H. Palencia, S. W. Ragsdale, J. M. Takacs, and J. L. Miner, University of Nebraska-Lincoln.

Ruminal methane production is responsible for a loss of 5 to 15% of feed gross energy during digestion. Additionally, methane is a greenhouse gas and livestock account for 17% of total methane emissions. Inhibition of ruminal methanogenesis could both increase feed efficiency and mitigate global warming. Methanogenic archaea utilize a unique pathway to synthesize methane. The enzyme, 4-(β-D-ribofuranosyl) aminobenzoate 5'-phosphate synthetase represents a promising target for inhibition. A natural substrate of this enzyme is pABA. We hypothesized that analogs of pABA could inhibit methanogenesis in ruminal cultures. Methanogenesis assays were conducted in 30-h, 4-ml anaerobic incubations of bovine ruminal inocula in buffer containing trypticase, cellobiose, and trace nutrients, with 5.4 ml of headspace pressurized to 190 kPa. Headspace methane was quantified by gas chromatography using a 6-m, silica gel column, thermal conductivity detection, and adjustment for headspace pressure. Sixteen pABA analogs were synthesized and tested at  $10^{-5}$  to  $10^{-2}$  M. Each experiment determined the effect of up to four analogs. A known inhibitor of methanogenesis, 2-bromoethanesulfonate (1mM) was used as a positive control and buffer addition was the negative control. Three analogs inhibited ( $P < 0.01$ ) methane synthesis. Five mM 4-ethylamino-benzoate and 9 mM 4-isopropylamino-benzoate each completely inhibited methane production. Five mM 4-(2-hydroxy-ethylamino)-benzoate inhibited methane production to 2.5% of the control. Bromoethanesulfonate completely inhibited ( $P < 0.01$ )

methane production in all experiments. We conclude that pABA analogs can inhibit methanogenesis in ruminal fermentations.

**Key Words:** Archaea, Methane, P-Aminobenzoate

**289 Response of breed and gender of beef cattle to copper sulfate supplementation.** M. J. Rincker\*, J. B. Barber, P. H. Coe, D. R. Hawkins, G. M. Hill, J. E. Link, and J. E. Rowntree, *Michigan State University, East Lansing, MI.*

Initial data (1993-97) evaluating copper (Cu) status of the Michigan State University beef herd indicated that, even though cupric oxide was provided in trace mineral salt, plasma Cu concentration of cows (age > 730 d) diminished each year (130 to 78 µg/dL) regardless of breed. Following 6 mo of supplementation with 48 g copper sulfate (CuSO<sub>4</sub>)/kg to the trace mineral salt (TMS/CuSO<sub>4</sub>), an increase in plasma Cu concentration (106 µg/dL) was observed in 1998. Thus, the objective of this study was to further evaluate the effects of continued CuSO<sub>4</sub> supplementation on plasma Cu concentration in this herd. Cattle were allowed ad libitum access to TMS/CuSO<sub>4</sub> and were bled in 1999 and 2000. Plasma samples from 510 females: Angus (A) = 165, Hereford (H) = 219, and crossbred (XB) = 126, and 74 males: A = 27, H = 47, were obtained for determination of Cu concentration by atomic absorption spectroscopy. No differences in plasma Cu were observed between 1999 and 2000 (102 vs 98 µg/dL). When combining the 1999 and 2000 data, a breed effect was noted (A = 98, H = 103, and XB = 95 µg/dL,  $P < 0.05$ ). The response to CuSO<sub>4</sub> also varied among age and sex: bull calves (age < 365 d) = 112, mature bulls (age > 365 d) = 107, cows = 98, heifers (365 < age < 730 d) = 99, and heifer calves (age < 365 d) = 103 µg/dL ( $P < 0.01$ ). Data from a core group of cows (n = 45) who were bled annually from 1996 to 2000 were analyzed. Plasma Cu concentration varied throughout the five year period (96, 77, 108, 93, and 91 µg/dL, respectively,  $P < 0.01$ ). Copper concentration of H cattle was lower in 1997 when compared with A cattle (68 vs 90 µg/dL,  $P < 0.01$ ), but following supplementation Plasma Cu in H cows increased from 1998 to 2000, while plasma Cu of A cows peaked in 1998 and then declined in 1999 and 2000. These results indicate that cattle do indeed require an available form of supplemental Cu to maintain adequate Cu stores. However, there may be differences in Cu utilization and retention between breeds.

**Key Words:** Copper Sulfate, Cattle

**290 Effect of age on glutathione peroxidase activity in Angus females.** J.E. Rowntree\*, D.R. Hawkins, G.M. Hill, and J.E. Link, *Michigan State University.*

Michigan is considered to be a Selenium (Se) deficient state, however little is known of the Se status in cattle transplanted from Se adequate areas to areas of deficiency. Our lab previously reported that age influences copper status in beef cattle. Hence, the objective of this study was to determine the influence of age and location of origin on Se status measured by glutathione peroxidase activity (GPX1) in Angus females. Two central Michigan cowherds (n = 49, n = 38) were studied. The cooperated herd (CH) was composed of 24 mature cows, 11 two year old cows, and 14 yearling heifers. Cattle were assembled from Se adequate regions outside of Michigan. The Angus cowherd at Michigan State University (MSU) was composed of 22 mature cows, 8 two year old cows, and 8 yearlings. These females originated from Michigan and were reared since birth in the herd. Blood was collected and red blood cell GPX1 activity was determined by the method of Paglia and Valentine. The cows in the CH had higher GPX1 activity ( $P < 0.01$ ) than MSU, therefore only within herd age comparisons were made. Yearling heifers in the CH herd had higher GPX1 activity ( $P < 0.01$ ) than mature cows (27.22 vs 18.74 GPX1 EU/g Hb, respectively). Yearling heifers did not differ from two-year-old cows (27.22 vs. 21.54 GPX1 EU/g Hb, respectively). In the MSU cowherd, yearlings had higher ( $P < 0.01$ ) enzyme activity as compared to two year olds and mature cows (23.20 vs. 15.45 and 15.83 GPX1 EU/g Hb, respectively). These results indicate that Angus cows raised in Se adequate areas and placed into Se deficient areas maintained higher GPX1 activity than Angus cows that originated in a Se deficient area. In this small study, Angus yearling females appeared to have higher GPX1 activity as compared with two year old and mature cows.

**Key Words:** Glutathione Peroxidase, Selenium, Angus cattle

**291 Influence of supplemental sunflower oil and dexamethasone therapy on performance and adipose tissue development of early weaned beef steers.** M. P. McCurdy\*, D. D. Buskirk, A. C. Grant, and J. D. Cowley, *Michigan State University.*

Twenty-four early weaned steers (average of 156 d of age; BW=237.3 ± 26.1 kg) were randomly assigned to a 2 x 2 factorial arrangement of dietary and drug therapy treatments for a period of 112-d. Diet consisted of basal diet only (control) or basal diet with the addition of 8% high-linoleate sunflower oil. Drug therapy consisted of three intramuscular injections of 0.1 mg dexamethasone/kg BW at 12-h intervals every 28-d or equal doses of physiological saline (control). Steers were fed individually and the amount fed was adjusted weekly so that treatment groups had isocaloric intake. Following the 112-d treatment period, all steers were fed a common basal diet until harvest. Lipid deposition was measured by ultrasound every 28-d throughout the trial and complete carcass data was collected after harvest. Dexamethasone decreased ADG by 0.17 kg ( $P < 0.01$ ), and decreased feed efficiency by 10% ( $P < 0.05$ ) during the 112-d treatment period. Over the entire trial, dexamethasone increased feed efficiency ( $P < 0.05$ ), however feed efficiency was decreased with the combination of dexamethasone and sunflower oil ( $P < 0.05$ ). Dexamethasone reduced ( $P < 0.05$ ) change in subcutaneous rib fat by 14%, and rump fat by 50%. Supplemental sunflower oil increased change in intramuscular fat by 41% ( $P < 0.01$ ). It was also observed that DMI during the 28-d intervals was correlated ( $P < 0.01$ ) with changes in intramuscular ( $r = 0.48$ ), subcutaneous rib ( $r = 0.68$ ), and rump fat ( $r = 0.60$ ). Carcass marbling score, rib fat, and yield grade of treatment groups were not significantly different than control. However, dexamethasone and sunflower oil both increased kidney, pelvic, and heart fat ( $P < 0.05$  and  $P < 0.07$ , respectively). Sunflower oil may be useful in increasing intramuscular fat. Additionally, dexamethasone treatment may result in subsequent improvement in feed efficiency and decreased subcutaneous fat over the feeding period.

**Key Words:** Dexamethasone, Sunflower Oil, Intramuscular Fat

**306 Effect of decreasing OM digestibility or direct addition of carbon source to pen surface on nitrogen balance in open-dirt feedlots.** J.R. Adams, G.E. Erickson, T.J. Klopfenstein, C.N. Macken, and C.B. Wilson, *University of Nebraska, Lincoln.*

Steers (n = 96, 325 ± 1.7 kg) were fed 180d through November to May to determine impacts of adding carbon (C) to pen surface through management (SWD) or diet (BRN) on manure nitrogen N removed or N lost via volatilization. Treatments were 75% dry-rolled corn (CON) and either 30% corn bran replacing dry-rolled corn (BRN) or CON diet with weekly sawdust applications (6.4 kg/steer) (SWD). Because CON and SWD diets were identical, performance was similar for these two treatments. Less energy dense BRN diet resulted in lower ADG than CON ( $P < 0.05$ ) and SWD ( $P < 0.09$ ). BRN had reduced feed efficiency when compared to other treatments ( $P < 0.01$ ) and no differences were seen in DMI ( $P > 0.3$ ). BRN excreted more N than CON due to higher N intakes. Addition of C increased manure N concentration above CON. Total N lost was calculated as N excretion minus manure N and runoff N. No significant differences were detected in kg of N lost due to variation, however, losses were decreased by 28% when comparing CON to BRN and SWD. BRN significantly reduced %N loss above CON. Losses from BRN and SWD were nearly identical, suggesting adding C directly to the pen surface or decreasing OM digestibility is beneficial in lowering N losses from open-dirt feedlots.

Item	CON	BRN	SWD	SE
N intake <sup>c</sup>	36.2 <sup>a</sup>	37.8 <sup>b</sup>	36.7 <sup>ab</sup>	0.5
N excretion <sup>c</sup>	32.2 <sup>a</sup>	33.9 <sup>b</sup>	32.6 <sup>ab</sup>	0.5
Manure N removed <sup>c</sup>	15.2 <sup>a</sup>	21.8 <sup>b</sup>	20.3 <sup>b</sup>	1.9
Runoff N <sup>c</sup>	0.4 <sup>a</sup>	0.3 <sup>b</sup>	0.3 <sup>b</sup>	0.05
N lost <sup>c</sup>	16.6	11.8	12.1	2.2
% N loss <sup>d</sup>	51.6 <sup>a</sup>	35.0 <sup>b</sup>	37.1 <sup>ab</sup>	6.2

<sup>a,b</sup> Within row, means with different superscripts differ ( $P < 0.10$ ).

<sup>c</sup>Kg/steer.

<sup>d</sup>N lost divided by N excretion.

## Teaching

**292 Teaching an applied swine nutrition and feeding management course using WebCT.** G.C. Shurson\*, J.S. Knott, M.J. Spiehs, B.J. Rae, and J.A. Renteria, *University of Minnesota, St. Paul, MN.*

We developed a Web-based applied swine nutrition and feeding management course for undergraduate and graduate students in animal science. The course is managed through WebCT at the University of Minnesota at <http://webct.umn.edu>, and is designed to be completed in fifteen weeks (6 to 8 hrs/wk). Each of the 39 lessons is primarily text-based, but most lessons have illustrations, graphs, data tables, and/or photos that help the student visualize key points. At the end of each lesson, there are several study questions for the student to use in reviewing key points of the lesson. These questions are also helpful for students preparing for each of the five exams. Exams are taken "on-line" during designated times mutually agreed upon by the students and instructor. Along with the exams, there are 14 problem sets related to practical nutritional decisions that can be printed, completed, and resubmitted electronically to the instructor for comments and grading. Students are able to download swine diet formulation software from the course Web

site for use in completing many of the problem sets. The course Web site features a chat room where students can ask questions of the instructor and other students, and the responses can be viewed by all who are enrolled in the course. In addition, students can track their exam and problem set scores, and their current course grade on the Web site. The course is also linked to all of the major feed industry Web sites to allow easy access for students who are interested in learning more about career opportunities in the feed industry. Using a Web-based course offers unique opportunities and challenges for both the instructor and the students compared to using more traditional learning environments. When students were asked if they were satisfied taking this course on the Web, 29% were very dissatisfied, 14% were dissatisfied, 14% were uncertain, and 43% were satisfied. Some of the major reasons for students being dissatisfied with this Web-based learning environment included spending too much time learning to use the technology, inadequate computer skills, and lack of adequate computer hardware and software on their personal computers.

**Key Words:** Teaching, Web-based, Nutrition

## Undergraduate Student Competitive Research Papers

**293 Development of a multiplex microsatellite marker panel for whole genome scans in sheep.** B. Mote\*<sup>1</sup> and B. Freking<sup>2</sup>, <sup>1</sup>University of Nebraska, Lincoln, <sup>2</sup>USDA, ARS, U.S. Meat Animal Research Center.

A primary objective of genome scans is to estimate the location of genes influencing a trait of interest using uniformly spaced informative genetic markers. Initial scans are typically conducted with an intermarker distance of approximately 20 cM. The sheep genome is reported to span 3500 cM for 26 autosomes and 130 cM for the female map of chromosome X. Multiplex amplification reactions decrease costs and time to conduct whole genome scan studies, but panels of markers which amplify together are not readily available for sheep. Microsatellite markers available from published ovine genetic maps were first sorted by annealing temperature and average product size, then arranged into groups of three primer pairs for amplification tests. Markers from chromosome 18 were excluded due to previous extensive mapping efforts associated with callipyge research in the population of interest. A total of 155 multiplex amplification reactions, with 465 unique primer pairs, were tested on sheep genomic DNA resulting in 57 successful duplex and 18 successful triplex marker sets. The current marker sets flank 2865 cM of the sheep genome. Seventeen chromosomes have been sufficiently covered to achieve the initial scan objective. With a targeted goal of 208 uniformly spaced markers, these results have reduced the number of reactions and gel lanes needed per animal from 208 to 115, or 55% of the previous number of marker reactions and gel lanes necessary for complete coverage. Average heterozygosity of the parental generation of the target resource population was 65.2%. It may be necessary to fill in gaps with additional markers where marker informativeness is low. This panel of markers can be a valuable resource for the sheep gene mapping community.

**Key Words:** Sheep, Microsatellites, Multiplex

**294 Flocculation of swine manure: influence of flocculant, rate of addition, and diet.** L. Flatow\*<sup>1</sup> and W. Powers<sup>1</sup>, <sup>1</sup>Iowa State University.

Manure was collected from growing pigs fed one of 11 diets varying in total and available phosphorus content. Reduced phosphorus diets were amended with feed additives intended to improve availability of phytate phosphorus. Diets were replicated over three feeding periods resulting in collection of 33 manure samples. During the course of the three feeding periods average pig weight increased from 22 kg to 48 kg. Actual dry matter and phosphorus content of each collected manure sample were determined. Ten g of each collected manure sample was diluted to a final volume of 1 L, producing a solution with average solids content of 0.24% total solids, and poured into Imhoff cones. Five flocculants plus a control were added, at each of three concentrations, to the diluted mixtures and allowed to settle for 10 minutes followed by a second

10-minute settling period. Volume of settled material was recorded following each settling period. At the end of the second settling period (20 min total settling) supernatant was poured off and frozen for future phosphorus analysis, and settled solids were weighed and dried for total solids determination. Mass of solids settled was measured. Mass of phosphorus settled was calculated as the differences between the P content in the 10 g originally added to the Imhoff cone and the g P in the supernatant. Results indicated that  $\text{Al}_2(\text{SO}_4)_3$  and  $\text{FeCl}_3$  were the most effective flocculants. Little improvement was observed when the flocculant was added at a concentration of 625 mg/L compared to 250 mg/L. Both flocculants recovered over 85% of solids and over 70% of the phosphorus. Addition of  $\text{Al}_2(\text{SO}_4)_3$  at a concentration of 625 mg/L increased phosphorus removal to 90%. Diet and feeding period were significant influences on results. As the pigs aged, manure phosphorus was more soluble, possibly explaining the observation that less phosphorus was settled in feeding period 3 compared to phosphorus settled in feeding periods 1 and 2. Removal efficiency of total solids and phosphorus with flocculation was predicted quite well using developed equations ( $r^2 = 0.86$  and  $0.84$ , respectively). As producers consider nutrient management options, feed-to-field strategies should be implemented.

**Key Words:** Manure, Flocculation, Phosphorus

**295 Effects of manure storage time and filling scheme on odor and headspace analysis using simulated manure storage pits.** S. Bastyr\* and W. Powers, *Iowa State University.*

Dilute swine manure, approximately 11% dry matter, was stored in constructed 2-L vessels for up to 91 d. Initiation of vessels was staggered to allow for simultaneous evaluation of manure stored for varying time periods. Vessels were filled, in duplicate, under two filling schemes; either filled completely on d 0 (SF) or filled over the course of 10 wk by adding 200 ml per wk (WF). On d 70, 34 vessels were operational. Once weekly, cotton swatches were placed in each vessel cap overnight for evaluation by human panelists using triangular forced-choice methodology. Each panelist assigned an odor score, on a scale of 1-10, to identified swatches ( $n=3736$ ). Headspace contents of each vessel were analyzed, weekly, by gas chromatography (GC-MS) and with a Cyranose 320 32-sensor electronic nose. Vessel contents were sampled for compositional analysis when each vessel was terminated. Results indicate that odor score was affected by days stored ( $P=0.002$ ), increasing until approximately d 42 before leveling off, and filling mode ( $P=0.008$ ). An interaction between filling mode and days stored was significant; swatches from the WF vessels had lower scores than swatches from the SF vessels until approximately d 49. Of the 32 analytes quantified using GC-MS, dimethyl disulfide and 4-methylphenol were best correlated to odor. Correlations were, however, low ( $r < 0.30$ ). A prediction equation from headspace concentrations of analytes produced an  $r^2$  value of 0.18. The odor predictive capability of the electronic nose was similar ( $r^2 = 0.20$ ). Given panelist variation, it is likely that the predictive capability of any

## Teaching

**292 Teaching an applied swine nutrition and feeding management course using WebCT.** G.C. Shurson\*, J.S. Knott, M.J. Spiehs, B.J. Rae, and J.A. Renteria, *University of Minnesota, St. Paul, MN.*

We developed a Web-based applied swine nutrition and feeding management course for undergraduate and graduate students in animal science. The course is managed through WebCT at the University of Minnesota at <http://webct.umn.edu>, and is designed to be completed in fifteen weeks (6 to 8 hrs/wk). Each of the 39 lessons is primarily text-based, but most lessons have illustrations, graphs, data tables, and/or photos that help the student visualize key points. At the end of each lesson, there are several study questions for the student to use in reviewing key points of the lesson. These questions are also helpful for students preparing for each of the five exams. Exams are taken "on-line" during designated times mutually agreed upon by the students and instructor. Along with the exams, there are 14 problem sets related to practical nutritional decisions that can be printed, completed, and resubmitted electronically to the instructor for comments and grading. Students are able to download swine diet formulation software from the course Web

site for use in completing many of the problem sets. The course Web site features a chat room where students can ask questions of the instructor and other students, and the responses can be viewed by all who are enrolled in the course. In addition, students can track their exam and problem set scores, and their current course grade on the Web site. The course is also linked to all of the major feed industry Web sites to allow easy access for students who are interested in learning more about career opportunities in the feed industry. Using a Web-based course offers unique opportunities and challenges for both the instructor and the students compared to using more traditional learning environments. When students were asked if they were satisfied taking this course on the Web, 29% were very dissatisfied, 14% were dissatisfied, 14% were uncertain, and 43% were satisfied. Some of the major reasons for students being dissatisfied with this Web-based learning environment included spending too much time learning to use the technology, inadequate computer skills, and lack of adequate computer hardware and software on their personal computers.

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method is limited to an  $r^2$  of 0.50. Therefore, the GC-MS equation and the electronic nose response were moderately effective in mimicking human response. Breakdown of solids and organic matter occurred to a greater extent when the manure was added in a single addition (SF), although odor scores were initially greater in the SF vessels. Nitrogen and ammonia content of the manure, stored for an equivalent period of time, was less in the SF vessels. Results indicate that manure-handling strategies, within the housing facility, may be developed to reduce mal-odor potential. Further work is needed to develop instrumental methods for odor assessment.

**Key Words:** Manure, Odor, Odorants

## 296 Selected fractionate digestibility coefficients of an extruded mixture containing whole soybeans and separated slurry solids. P Walker, D Finnigan\*, J Dust, and R Knight, <sup>1</sup>Illinois State University, Normal, IL/USA.

Suffolk wethers 8-9 months old and weighing  $59.25 \pm 4.4$  kg were used in a trial to determine the apparent digestible energy and digestibility coefficients of dietary DM, CP, ADF and ether extract (EE) of an extruded mixture containing whole soybeans (WS) and separated swine slurry solids (SSS). Solids were separated from co-mingled gestation to finishing swine slurry using a gravity screen-rollerpress Key Dollar<sup>TM</sup> separator. Separated slurry solids were mixed with whole soybeans in a 50:50 ratio (wet wt. basis), passed through a single screw, dry extruder at 146-149 °C and dried in a hot air continuous belt dryer. Lambs were randomly allotted to metabolism crates and were fed the mixture at 3.4% of body wt, for 30d with total fecal collection the last 7d. Gross energy was determined on all samples with an adiabatic bomb calorimeter. On a percent basis, SSS contained:  $42.46 \pm 6.57\%$  DM,  $8.80 \pm 2.33\%$  CP,  $4.20 \pm 1.28\%$  EE,  $25.14 \pm 2.20\%$  ADF,  $13.74 \pm 3.34\%$  CELL,  $10.90 \pm 2.35\%$  LIG,  $0.50 \pm 0.25\%$  AIA, and  $8.03 \pm 3.29\%$  ASH. Apparent digestibility coefficients of the extruded mixture were  $52.03 \pm 6.55\%$  DM,  $68.46 \pm 8.36\%$  CP,  $77.48 \pm 9.71\%$  EE, and  $48.94 \pm 8.56\%$  ADF. Crude fat as estimated by EE was more digestible ( $P < 0.05$ ) than other fractions evaluated. The extruded mixture was found to contain  $52.03 \pm 6.55\%$  DM,  $21.43 \pm 2.79\%$  CP,  $8.43 \pm 1.47\%$  ADF,  $11.48 \pm 1.4\%$  EE on a dry matter basis. Apparent digestible energy of the extruded mixture was  $2.66 \pm .37$  Mcal/kg. This study suggests extruded mixtures composed of separated slurry solids and whole soybeans can be an acceptable method for including separated slurry solids into livestock diets.

**Key Words:** Separated Slurry Solids, Extruded, Feed

## 297 Digestibility of Amino Acids in Soybean Meal with added Soy Hulls. R. Dilger\*, J. Sands, D. Ragland, and L. Adeola, Purdue University, West Lafayette, IN.

Soy hulls (SH) were incorporated into four 17%-CP diets at 0, 3, 6, or 9% and fed to 35-kg barrows to determine their effect upon apparent and true digestibilities of amino acids measured at both the terminal ileum and over the total tract. A low protein casein diet was fed to estimate endogenous amino acid losses and two control diets were also administered. Pigs were surgically fitted with simple T-cannula at the terminal ileum and fed the seven-semipurified cornstarch diets according to a 7 X 7 Latin square design. Each period lasted 7 d, with fecal samples collected on d 5 and ileal samples collected for 12-h on both days 6 and 7. Feed was restricted to 90% of metabolic body weight and fed in two equal portions at 0800 and 2000. The apparent ileal digestibilities of dry matter (DM), nitrogen (N), and amino acids (AA) (except tryptophan) decreased with the addition of SH (quadratic effect,  $P < 0.05$ ). DM, energy (E), and most of the AA also showed a linear decrease ( $P < 0.05$ ) in digestibility. Apparent total tract digestibilities of DM, E, N, and AA produced a decreasing quadratic effect ( $P < 0.05$ ), and all of these nutrients except E, N, and tryptophan also exhibited a linear decline in digestibility ( $P < 0.05$ ). True ileal digestibilities of N and AA (except tryptophan) showed a quadratic decrease ( $P < 0.05$ ) from the addition of SH. Arginine, tryptophan, cysteine, serine, aspartate, and glutamate showed a linear decline in true ileal digestibility ( $P < 0.05$ ). All true total tract digestibilities of AA decreased (linear and quadratic effects,  $P < 0.05$ ), except for N and tryptophan (linear effect only,  $P < 0.05$ ). In conclusion, the addition of soy hulls up to the 6% level reduced DM, E, N, and AA digestibilities of soybean meal. The inclusion of 3 or 6% SH reduced the average apparent ileal digestibility of the indispensable AA 7.8 or 15.2 percentage units, respectively, but 9% SH led to a reduction

of only 1.6 percentage units. Similarly, SH led to 5.7 or 11.3 percentage unit decreases for the average true ileal digestibility of the indispensable AA at the 3 or 6% SH levels, respectively, while 9% SH resulted in only a 1.4 percentage unit decrease.

**Key Words:** Soybean Meal, Amino Acid Digestibility, Swine

## 298 Mapping of the *HMG-I* gene family in the pig. N.-T. Nguyen\*, K.-S. Kim, Y. Zhang, and Max F. Rothschild, Iowa State University, Ames Iowa.

The HMG-I gene family consists of two genes that encode three proteins (HMG-I, -Y, and -C) associated with chromatin structure and control of transcription. The HMG-I and -Y proteins are products of an alternative spliced RNA of the same gene, but a separate gene encodes for HMG-C. Recent studies indicate the *HMG-I* gene products may be involved in the pathogenesis of several human cancers and the chromosomal regions localized for the human *HMG-I* genes are also known to be involved in several chromosomal abnormalities correlated with many human cancers. This study was designed to map the HMG-I genes to specific pig chromosomes. Primers for PCR amplification of the porcine *HMG1Y* and *HMGIC* were designed from human and rodent sequences. PCR-RFLP tests were developed to genotype the single nucleotide polymorphisms (SNPs) identified in both genes. Two-point and multi-point linkage analyses were performed from the Iowa State University Berkshire and Yorkshire crossed reference families. In addition, both genes were physically mapped using PCR with the pig/rodent somatic cell hybrid panel. The *HMG1Y* gene was assigned to SSC 7 by both linkage and physical methods, which is in agreement with other comparative mapping studies. Interestingly, the pig *HMGIC* fragment (1.2 kb) spanning exon 5 and the 3' UTR was assigned to the SSC 1 by both methods. This result is striking because human *HMGIC* maps to HSA 12q15, so the pig *HMGIC* was expected to map on SSC5, a region corresponding to HSA12q. Previously a 500 bp fragment of 5' UTR of the pig *HMGIC* had been physically mapped on SSC5 (D. Pomp, personal communication). The discrepancy could suggest the presence of a pseudogene. However, it might also be evidence of the possible chromosomal rearrangement (or break) within the pig *HMGIC* gene since *HMG-I* genes have been evolved through gene duplication and exon shuffling events. The human *HMGIC* gene is known to contain chromosomal breakpoints associated with many cancers.

**Key Words:** Hmg1y, Hmgic, Pig

## 299 Fish oil, conjugated linoleic acid, and body fat deposition. B. J. Meyer\*, K. M. Hargrave, and J. L. Miner, University of Nebraska.

Conjugated linoleic acid (CLA), which causes body fat depletion, can be metabolized in a manner similar to linoleate thereby yielding isomers of arachidonate. Dietary linoleate deficiency enhances sensitivity to CLA. Therefore, we hypothesized that CLA depletes body fat by inhibiting synthesis of arachidonate from linoleate or, alternately, by being metabolized to an arachidonate isomer. If the former is true, reducing arachidonate stores should sensitize mice to dietary CLA. Fish oil diets can decrease the stores of arachidonate. The present objective was to determine if mice fed a diet containing fish oil are more sensitive to the effect of CLA on body fat than mice fed a diet containing soy oil. Eighty, newly-weaned male mice (3 wk of age, 15 g BW) were blocked by weight and genetic background, and allotted to four diets: SOY = 20% soy oil diet for 9 wk; SOY + CLA = SOY for 7 wk then 19.5% soy oil with 0.5% CLA for 2 wk; FISH = 20% fish oil diet for 9 wk; FISH + CLA = FISH for 7 wk then 19.5% fish oil with 0.5% CLA for 2 wk. Feed intake and BW were determined weekly. After 9 wk, the mice were killed and liver and fat pads (epididymal and retroperitoneal) were collected. Body fat and lean weight were determined by Dual Energy X-ray Absorptiometry. Analysis of variance detected no significant interactions with genetic background, therefore mean comparisons were limited to diet effects. Lean weight was not affected by diet. Compared to mice fed SOY, body fat and fat pad weights were reduced ( $P < 0.01$ ) by 19% in mice fed FISH, and by 15% in mice fed SOY + CLA, but were not reduced by FISH + CLA (fat source x CLA interaction;  $P < 0.01$ ). Liver weight was increased ( $P < 0.01$ ) by 10% due to fish oil, but was not affected by CLA. We conclude that sensitivity to CLA is not greater in mice fed fish oil versus soy oil. Our interpretation is that the mechanism by which CLA depletes body fat is independent of arachidonate stores and thus independent of arachidonate production from linoleate.

These results support the alternate hypothesis that CLA metabolism to an arachidonate isomer leads to body fat depletion.

**Key Words:** Mice, Conjugated Linoleic Acid, Adipose

**300 Identification of genes regulated by zinc supplementation of weaned pigs.** M.A. Closs\*, C.P. Wilkinson, N.E. Raney, G.M. Hill, J.E. Link, M.M. Martinez, K.M. Hargrave, and C.W. Ernst, *Michigan State University, East Lansing.*

Supplementation of weanling pig diets with pharmacological levels of zinc (Zn) as Zn oxide (ZnO) results in increased growth performance. We hypothesize that the positive effects of Zn are, at least in part, the result of gene expression regulation by Zn. The objective of this experiment is to identify differentially expressed genes regulated by dietary Zn supplementation of weaned pigs (approx. 21 d of age) using the differential display reverse transcription polymerase chain reaction (DDRT-PCR) technique. In study 1, liver tissue was obtained from pigs fed either an adequate Zn diet (150 ppm) or a diet containing 2,000 ppm Zn as ZnO (n = 4 per treatment) for 14 d post-weaning. In study 2, liver tissue was obtained from pigs fed either an adequate Zn diet (150 ppm) or a diet containing 1,000 ppm Zn as ZnO (n = 4 per treatment) for 14 d post-weaning. Total RNA was extracted from liver tissue and used in DDRT-PCR analyses. Five primer pairs (1 oligo-dT anchor with 5 arbitrary primers) were used in study 1 and three primer pairs (1 anchor with 3 arbitrary) were used in study 2 to identify putative differentially expressed genes. Thirteen fragments (6 from study 1 and 7 from study 2) that were amplified in all samples of one treatment but were faint or undetectable in all samples of the other treatment were excised, PCR-reamplified and cloned. Clones were sequenced and compared to entries in the GenBank databases using the BLAST software. Sequences for 10 of the 13 clones significantly matched entries in the GenBank non-redundant or expressed sequence tag (EST) databases and the remaining 3 clones did not match any entry in the databases. Three clones shared significant homologies to known genes (alpha-1 acid glycoprotein, nickel specific induction protein and tight junction protein 1) and 7 matched ESTs of unknown identity. These results provide new information concerning Zn regulation of liver gene expression in nursery pigs and could help elucidate the mechanism by which dietary Zn improves pig growth.

**Key Words:** Nursery Pigs, Zinc, DDRT-PCR

**301 Effect of ryanodine, nifedipine, and low sodium on contracture force in isolated muscle bundles from horses with recurrent exertional rhabdomyolysis.** G.A. Searls\* and G.W. Onan, *University of Wisconsin River Falls, Wisconsin.*

Previous studies have shown that isolated muscle bundles from Thoroughbred horses with an inherited form of Recurrent Exertional Rhabdomyolysis (RER) develop contractures in the presence of either halothane or lower concentrations of caffeine than isolated bundles from normal horses. Therefore contracture tests similar to those used for identification of humans subject to malignant hyperthermia have been developed for early identification of foals carrying the RER gene. The purpose of this study was to determine if any other substances might have a differential effect on *in vitro* contractures of muscle bundles from RER vs. normal horses in order to better refine diagnoses of foals and to further indicate a potential source for the defect in RER muscle. A series of pharmaceuticals known to have effects on calcium channel proteins or calcium transport proteins were investigated. Muscle bundles from RER horses developed significantly stronger contractures in the presence of 0.05  $\mu$ M and 0.1  $\mu$ M ryanodine ( $P < .05$ ) than did bundles from normal horses. This is consistent with the reaction of malignant hyperthermia muscle from human and swine subjects, offering further evidence that the RER condition in Thoroughbreds is a related disease and that the defect lies in the calcium buffering ability of the sarcoplasmic reticulum. A further series of studies investigated the effects nifedipine (a dihydropyridine calcium channel blocker) and low extracellular sodium (which affects the sarcolemmal sodium-calcium transporter protein) on the extent of caffeine-induced contractures in RER vs. normal muscle bundles. The presence of 10  $\mu$ M nifedipine or low (15mM) sodium both caused increased contracture force at 1.0 mM, 2.0 mM, and 5.0 mM caffeine ( $P < .05$ ) in muscle bundles from all horses with no differential effect between types. These results would indicate that sarcolemmal calcium regulating proteins are not important in the etiology of RER onset in affected horses and further substantiate that the defect lies with the

sarcoplasmic reticulum. Furthermore ryanodine may be a useful adjunct in early diagnosis of the disease in foals.

**Key Words:** Recurrent Exertional Rhabdomyolysis, Ryanodine, Nifedipine

**302 Reed-sedge peat as a feed additive for dairy cows.** P. W. Clark and G. L. Golombeski\*, *U. W.- River Falls.*

The effect of reed-sedge peat as a feed additive (MenefeedR) for dairy cows was investigated with reference to milk yield, milk composition, and somatic cell count (SCC). Thirty-four cows were divided into two groups balanced for parity and milk yield in a crossover design with four three-week periods. The MenefeedR was fed once daily at a rate of 4 ounces per head in a .90 kg mixture of oats, corn, and molasses for the Treatment group. The Control group received the same grain mix without the MenefeedR. Milk samples were taken at the end of every three-week period for eight consecutive milkings and milk weights were recorded. Milk samples were analyzed for fat and protein concentration and SCC. There was no significant difference ( $P > .05$ ) between the Control (34.9 kg/d) and Treatment (34.0 kg/d) groups for energy corrected milk yield. There was also no significant difference between Control (2.88) and Treatment (2.92) groups for mean linear SCC score.

**Key Words:** Reed-Sedge Peat, Somatic Cell Count

**303 A comparison of different particle size analysis techniques.** A.L. Baldrige\*, T.L. Stainbrook, J.C. Woodworth, M.D. Tokach, J.L. Nelssen, R.D. Goodband, and S.S. Dritz, *Kansas State University, Manhattan.*

Particle size of ground grain is determined in labs using the ASAE approved, 13-sieve method. Because this method is time consuming, a 1-sieve, hand-shaking method has been developed (1s; IFA, Stanly, IA). Questions on the accuracy of the 1-sieve method led us to develop an alternative method to quickly determine particle size with 3 sieves and to compare the various methods. Forty-three samples of ground corn were analyzed by the approved 13-sieve procedure (13s; 3350  $\mu$ m to 53  $\mu$ m opening mesh screens) with mean particle size of samples ranging from 1143 to 422  $\mu$ m. The same samples were analyzed by the 1s method and the developed 3-sieve (3s) method. For 13s, the approved ASAE protocol was followed: 100 g of corn was placed on top of the sieve stack and shaken for 10 min on a Rotap sieve shaker. For 1s, IFA protocol was followed: 280 g of corn was placed on a sieve (1400  $\mu$ m opening) and shaken by hand until no more sample fell through. For 3s, 50 g of sample was placed on top of a stack (1700, 600, and 300  $\mu$ m opening) and shaken by hand for 1.5 min. Mean particle size was calculated based on the amount of sample resting on each screen after shaking. For 1s, the IFA procedure also was compared to a new prediction equation ( $11.86 \times \text{wt on screen, g} + 435$ ;  $R = 0.74$ ). For 3s, the prediction equation was  $18.89 \times (X1700) + 10.87 \times (X600) + 1.18 \times (X300) \div 150$  ( $R = 0.88$ ) where X equals the percentage of sample on the respective screens. The different methods were compared by calculating the residual of the predicted particle size from the particle size determined from the 13s method. The residual for 3s (44  $\mu$ m) was lower ( $P < 0.01$ ) than 1s using both the IFA protocol (133  $\mu$ m) and the new prediction equation (74  $\mu$ m). Residual of 1s using the prediction equation also was lower ( $P < 0.01$ ) than 1s using IFA protocol. In conclusion, 3s is a quick method that can be used to predict particle size with less variation than the 1s method commonly used. The 1s method can be improved by using a different prediction equation than that provided by the company.

**Key Words:** Grain, Particle size, Procedures

**304 Effect of ruminal protein degradability and supplementation frequency on intake, diet digestibility, and nitrogen balance in forage-fed lambs.** D. E. Carter\*, P. A. Ludden, V. Nayigihugu, and B. W. Hess, *University of Wyoming.*

Twenty-four wether lambs (initial BW =  $36.8 \pm 0.7$  kg) were used in a 56 d split block,  $2 \times 2$  factorial designed experiment to evaluate the effects of ruminal protein degradability (RDP) and supplementation frequency on intake, diet digestibility, and N retention. All lambs were fed chopped (7.6 cm) bromegrass hay (7.4% CP, 61.1% RDP, 59.3% NDF, 33.7% ADF) for ad libitum consumption, and either soybean meal (high RDP) or feather meal (low RDP) daily or on alternate days. Supplements were fed on an isonitrogenous basis (0.28 and 0.20% of BW daily

for the high and low RDP supplements, respectively), with alternate-day supplements fed at twice the level of daily supplementation. Beginning on d 21 and 49 of the trial, two 8-d N balance collections were conducted. No protein degradability  $\times$  supplementation frequency interactions ( $P \geq 0.24$ ) were noted in this experiment. No treatment effect was noted for forage DM intake ( $P \geq 0.21$ ), total DM intake ( $P \geq 0.08$ ), N intake ( $P \geq 0.79$ ), or total tract DM digestibility ( $P \geq 0.10$ ). Total tract N digestibility was not affected ( $P \geq 0.42$ ) by protein degradability, but was increased ( $P = 0.01$ ) with alternate day supplementation (57.2 vs 54.6%). A protein degradability  $\times$  collection period interaction was observed for N retention (g/d and % of N intake;  $P \leq 0.05$ ), wherein feeding the low RDP supplement produced a greater increase in N retention during the second collection period. Overall, protein degradability did not affect ( $P \geq 0.29$ ) urinary N excretion or N retention; however, alternate day supplementation decreased ( $P = 0.02$ ) urinary N excretion, thereby increasing N retention in g/d (6.57 vs 5.32;  $P = 0.01$ ), as a % of N intake (33.8 vs 27.0;  $P = 0.003$ ) and as a % of digested N (58.8 vs 49.4;  $P = 0.01$ ). Supplementing protein to forage-fed ruminants on alternate days appears to enhance efficiency of N utilization, irrespective of ruminal protein degradability.

**Key Words:** Ruminal Protein Degradability, Supplementation Frequency, Nitrogen Retention

**305 Effects of harvest date and late-summer fertilization rate on dry matter yield and chemical composition of stockpiled bermudagrass forage.** A.A. Gelvin<sup>\*1</sup>, D.L. Lalman<sup>1</sup>, C.F. Taliaferro<sup>1</sup>, and J. Ball<sup>2</sup>, <sup>1</sup>Oklahoma Agricultural Experiment Station, <sup>2</sup>Noble Foundation, Ardmore, OK.

A randomized complete block design with four replications was used to test the effects of N fertilization rate and harvest date on yield and

chemical composition of stockpiled Greenfield bermudagrass at the Eastern Research Station near Haskell, OK. Four N fertilization rates were applied on August 17, 1998 (0, 34, 67, 135 kg/ha) and forage was sampled at five 28-d intervals beginning on November 5. During late April, prior to the experiment, 112 kg N/ha was applied and P & K was applied as indicated by soil test. Hay was harvested from the plots during early June and again during early August. Near infrared reflectance spectroscopy (NIRS) was used to determine chemical composition including CP, soluble protein (SP), neutral detergent insoluble crude protein (NDICP), ADF, NDF, lignin (LIG), non-structural carbohydrate (NSC), fat, and ash. Total digestible nutrients was calculated using the summative approach. Fifteen percent of the samples were analyzed for each component using wet chemistry procedures to calibrate the NIRS equations. Degradable protein concentration (DIP) was determined using the *Streptomyces griseus* enzymatic procedure. Monthly precipitation was 16.1, 21.4, 9.2, 5.9, 6.6, and 5.8 cm for September, October, November, December, January, and February, respectively. Forage dry matter yield, determined on November 5, increased linearly ( $P < .01$ ;  $y = 37.454x + 3120$ ) with increasing N fertilization. Concentration of CP, SP, DIP, NDICP, and TDN increased ( $P < .05$ ) with increasing N fertilization. However, concentration of cell wall constituents and fat decreased ( $P < .01$ ) with increasing N fertilization. Ash and NSC were not affected by N fertilization rate ( $P > .2$ ). As the winter progressed, concentration of CP, SP and NDICP decreased ( $P < .01$ ), although DIP increased ( $P < .01$ ) over time. Later harvest dates were associated with increased ( $P < .01$ ) ADF and NDF concentration and decreased ( $P = .01$ ) NSC, with no change in LIG or TDN ( $P > .2$ ). Increased N fertilization resulted in greater stockpiled bermudagrass yield and nutritive value, although the effects of harvest date were variable.

**Key Words:** Stockpiled Bermudagrass, Forage Nutritive Value, Protein Fractions