

at -43d (3.77 vs 3.80), calving (3.68 vs 3.67), 100 DIM (2.78 vs 2.79). Feeding LTFA compared to PO had no effect on incidence of clinical ketosis (8.2 vs 6.9%), displacement abomasum (3.1 vs 1.6%), and milk fever (1.9 vs 2.0%). Cows fed LTFA had reduced yields of fat and 3.5%

FCM, altered milk fatty acid profile, but changes in FCM yield did not reflect in positive effects on BCS or health.

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**Key Words:** Fatty Acids, Dairy Cows, Trans Fatty Acids

## Horse Species

**75 Insulin resistance in growing Thoroughbreds is affected by diet.** K. Treiber<sup>\*1</sup>, R. Boston<sup>2</sup>, D. Kronfeld<sup>1</sup>, R. Hoffman<sup>1</sup>, W. Staniar<sup>1</sup>, and P. Harris<sup>3</sup>, <sup>1</sup>Department of Animal and Poultry Sciences, Virginia Polytechnic Institute and State University, Blacksburg, <sup>2</sup>Department of Clinical Studies, New Bolton Center, Kennett Square, PA, <sup>3</sup>Equine Studies Group, WALTHAM Centre for Pet Nutrition, Melton-Mowbray, UK.

Insulin resistance is associated with obesity and inactivity and may be a risk factor for metabolic disorder in horses. This study applied the minimal model to test the affect of diet on glucose and insulin in young horses. Twelve Thoroughbred foals were raised on pasture and supplemented twice daily with a feed high in either sugar and starch or fat and fiber. As weanlings (age 199 ± 19 d, weight 274 ± 18 kg) the subjects underwent a modified frequently sampled intravenous glucose tolerance test during which they remained in stalls and had access to grass hay and water ad libitum. Samples were collected at -60, -45, 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 19, 22, 23, 24, 25, 27, 30, 35, 40, 50, 60, 70, 80, 90, 100, 120, 150, 180, 210, 240, 270, 300, 330 and 360 min with a glucose bolus of 300 mg/kg BW at 0 min and an insulin bolus of 1.5 mU/kg BW at 20 min. Plasma was analyzed for glucose and insulin. Insulin sensitivity (SI), glucose effectiveness, acute insulin response to glucose (AIRg) and disposition index were derived using Minmod Millennium and WinSAAM software. Diets were compared using the non-parametric Kruskal-Wallis test and the sign test. Basal glucose did not differ between groups (P = 0.75). Insulin levels were higher in the sugar and starch adapted weanlings at all 36 sample points (P = 0.030). The fasting glucose:insulin ratio for the sugar and starch supplemented weanlings was lower than for fat and fiber weanlings (P = 0.025). Insulin sensitivity was lower in weanlings fed sugar and starch than weanlings fed fat and fiber (P = 0.007). Acute insulin response to glucose was inversely correlated with SI (r = -0.54; P = 0.068). The glucose:insulin ratio was directly correlated to SI (r = 0.63; P = 0.036). These results show that weanlings adapted to a supplement high in sugar and starch had lower insulin sensitivity compared to weanlings adapted to a fat and fiber feed. Weanlings adapted to sugar and starch appeared to compensate for a lower sensitivity to insulin by increasing insulin secretion. Feeding meals high in glucose equivalents may increase the risk of developing insulin resistance and associated disorders in horses.

**Key Words:** Horse, Insulin Resistance, Minimal Model

**76 Somatotropic axis in growing Thoroughbreds is affected by diet.** K. Treiber<sup>\*1</sup>, W. Staniar<sup>1</sup>, D. Kronfeld<sup>1</sup>, R. Boston<sup>2</sup>, and P. Harris<sup>3</sup>, <sup>1</sup>Department of Animal and Poultry Sciences, Virginia Polytechnic Institute and State University, Blacksburg, <sup>2</sup>Department of Clinical Studies, New Bolton Center, Kennett Square, PA, <sup>3</sup>Equine Studies Group, WALTHAM Centre for Pet Nutrition, Melton-Mowbray, UK.

The somatotropic axis comprises a network of metabolites and hormones that link nutrition to growth. Feeds high in glucose equivalents cause exaggerated fluctuations in components of this network and may contribute to metabolic and growth disorders. This study analyzed samples from a frequently sampled intravenous glucose tolerance test (FSIGT) to determine the effect of diet on plasma concentrations of insulin, growth hormone (GH) and insulin-like growth factor-I (IGF-I) in growing horses. Twelve Thoroughbred foals were raised on pasture and supplemented twice daily with a feed high in either sugar and starch (SS) or fat and fiber (FF). As weanlings (age 199 ± 19 d, weight 274 ± 18 kg) the subjects underwent an FSIGT during which they remained in stalls and had access to grass hay and water ad libitum. Samples were collected at -60, -45, 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16, 19, 22, 23, 24, 25, 27, 30, 35, 40, 50, 60, 70, 80, 90, 100, 120, 150, 180, 210, 240, 270, 300, 330 and 360 min with a glucose bolus of 300 mg/kg BW at 0 min and an insulin bolus of 1.5 mU/kg BW at 20 min. The minimal model was used to estimate insulin sensitivity (Si). Plasma was analyzed for

glucose, insulin, GH and IGF-I concentrations. Feed groups were compared using the non-parametric Kruskal-Wallis test. Time interactions for IGF-I were compared by ANOVA with repeated measures. Robust linear regression was used for correlations. Growth hormone concentrations were increased from basal 19 to 180 min after the glucose dose (P < 0.05). Basal IGF-I was higher (P = 0.006) in the SS group compared to the FF group. Concentrations of IGF-I increased with time (P = 0.002) in the SS group. Basal IGF-I was inversely correlated to SI (-r = 0.52; P = 0.10). These results show that weanlings adapted to meals high in glucose equivalents have higher IGF-I secretion as compared to weanlings adapted to a fat and fiber supplement. This deviation may be associated with insulin resistance and metabolic dysfunction in horses fed concentrates high in hydrolyzable carbohydrates.

**Key Words:** Diet, Growth Hormone, Insulin-Like Growth Factor-I

**77 Environmental factors and nutrient composition of pasture in northern Virginia.** T. A. Cubitt<sup>\*</sup>, W. B. Staniar, and D. S. Kronfeld, Department of Animal and Poultry Science, Virginia Polytechnic Institute and State University, Blacksburg.

Greater than 90% of horses in Virginia receive all or part of their nutrition from pasture (USDA/APHIS, 1988). The objective of this study was to test for association between environmental factors and pasture variables, and to compare equine requirements for growth and reproduction, as recommended by the NRC (1989), to nutrient content determined by proximate analysis of pasture samples taken at monthly intervals for 5 y in northern Virginia. Day length (DL, h) and temperature (T, C) were measured. Statistical analysis included Pearson correlations, linear regressions and quadratic curves (SAS, 2000). Significant associations were found between DL and CP (r = -0.16, P = 0.02), ADF (r = 0.24, P = 0.0004), and NSC (r = -0.15, P = 0.04). Temperature significantly correlated with DM (r = 0.76, P = 0.0001), CP (r = -0.23, P = 0.0007), ADF (r = 0.32, P < 0.0001), and NSC (r = -0.19, P = 0.004). A quadratic relationship was fit between CP and T with an R<sup>2</sup> = 0.20, P < 0.0001. A linear regression fit to ADG (kg/d) versus CP resulted in an R<sup>2</sup> = 0.11, P < 0.0001. The data was adjusted for the delay in change in ADG as compared to CP, to give a clearer indication of the strength of the association and the resulting R<sup>2</sup> = 0.23, P < 0.0001. In comparison to the requirements for growth and reproduction the pastures tested were deficient in Zn, Cu and P. Crude protein was above the requirements set by the NRC (1989). This study presents a temporal relationship between environmental factors, nutrients in the pasture, and growth variables. We suggest that certain minerals are below the recommended minimums listed in the NRC for horses at certain times of year. This data is useful in developing sound management practices for horses raised on pasture.

**Key Words:** Nutrient Requirements, Horses, Pasture

**78 The effects of age, breed, gender and use on gastric ulceration in the horse.** K. Chamero<sup>\*</sup>, J. Nadeau, S. Bushmich, J. Dinger, and T. Hoagland, University of Connecticut, Storrs.

Gastric ulceration in horses has been identified as a serious health concern. The goal of this study was to determine if there was an effect on the occurrence of ulcers among a genetically diverse population of horses composed of several different ages, breeds, gender, and use. Eighty horses ranging in age from 2 years to 23 years were used. Their breeds consisted of Morgans, Quarter horses, Warmbloods, Thoroughbreds, and grade horses. Mares and geldings were included. All horses were used in one of three different capacities: polo, lessons, or training. Horses were examined by endoscopic examination, visible ulcers were scored according to an accepted gastric ulcer scoring system. Comparisons of the distribution of the occurrence of ulcers, lesion number, and lesion severity scores were made with chi square analyses using an expected occurrence of 30% based on two previous studies. Nine of the 80 horses

(11%) had ulcers located in the nonglandular squamous epithelial mucosa. The mathematical mean of the lesion number score was 2.22 and the mathematical mean of the lesion severity score was 2.67. For all age groups, the occurrence of ulcers was not different than expected. Occurrence of ulcers was not different in Morgans, Quarter horses, and Warmbloods. Thoroughbreds and grade horses had fewer ( $P < 0.05$ ) ulcers than expected. The occurrence of ulcers among all breeds was lower ( $P < 0.01$ ) than expected. Geldings had fewer ( $P < 0.01$ ) ulcers than expected, while the occurrence of ulcers was not different than expected in mares. The occurrence of ulcers for both genders was lower ( $P < 0.01$ ) than expected. Occurrence of ulcers was less than expected in horses used in lessons ( $P < 0.01$ ) and in polo ( $P < 0.05$ ). The occurrence of ulcers was not different in horses in training. For all three use categories, the occurrence of ulcers was lower ( $P < 0.01$ ) than expected. Among all categories, lesion number and lesion severity was not different than expected. Since overall percent and occurrence of ulcers in this population was lower than in previous studies, it may be suggested that such things as management practices, length of turnout, and overall contact may play an important role in the occurrence of ulcers.

**Key Words:** Gastric Ulcers, Horse, Breed

**79 Evaluation of feeding bee pollen to horses in training.** K. K. Turner\*, B. D. Nielsen, C. I. O'Connor, and J. L. Burton, *Michigan State University, East Lansing.*

"Bee pollen" is often fed to horses but few studies have evaluated its use. Our hypothesis was feeding bee pollen would positively influence nutrient digestibility, and indices of immunological status and physical fitness in horses in training. Ten Arabians (6 geldings, 4 mares) underwent a standardized exercise test (SET). Horses were pair-matched by sex and fitness and randomly assigned to P (receiving 118 g of bee pollen (Dynamic Trio 50/50) daily) or C (control receiving 73 g of a placebo) for a supplementation period of 42 d. A total collection period was conducted on geldings from d 18 to 21 to determine effects of bee pollen on nutrient retention and digestibility of NDF and ADF. Horses were exercise conditioned during the 42-d trial and completed another SET on d 42.  $V_{160}$  and  $V_{200}$  were calculated from SET heart rates (HR). Lactate, glucose, hematocrit (HT) and hemoglobin (HB) concentrations were determined from SET blood samples. Total and percent leukocytes, T and B lymphocytes, monocytes, neutrophils, and eosinophils, as well as IgG, IgM and IgA concentrations were determined from rest and recovery samples from both SETs. Geldings in P ate more feed than C on every day of the collection period. P had 80 % less phosphorus excretion ( $P = 0.003$ ), and tended to retain 90 % more nitrogen ( $P = 0.08$ ). P tended to digest more NDF ( $P = 0.06$ ) and ADF ( $P = 0.09$ ). P had lower NDF digestibility ( $P = 0.002$ ) and tended to have lower ADF digestibility ( $P = 0.07$ ). Although no treatment differences existed,  $V_{160}$  and  $V_{200}$  increased ( $P < 0.05$ ), and HR ( $P = 0.002$ ), blood lactate concentration ( $P < 0.0001$ ), HT ( $P < 0.0001$ ) and HB ( $P = 0.0003$ ) decreased from d 0 to 42. Few treatment differences were seen in immunological parameters. There was a trend for percent monocytes to increase in C while decreasing in P ( $P = 0.1$ ) from rest to recovery on d 42. Percent

## Milk Protein and Enzymes

**81 Composition of the air interface in ice cream as affected by protein and emulsifier content.** Z. Zhang\* and D. Goff, *Department of Food Science, University of Guelph, Guelph, ON, Canada.*

Emulsifiers and proteins interact during the production of ice cream to form the fat interface, which in turn controls the extent of partial coalescence and hence fat structure formation in the frozen product. The interaction of these ingredients at the air interface, however, has not been as well investigated. We have examined the effect of saturated or unsaturated mono-glyceride and the effect of protein from skim milk powder or whey protein isolate on the composition of the air interface by immuno-gold labeling and transmission electron microscopy. When ice cream was made from skim milk powder in the absence of emulsifier, casein micelles, non-micellar b-casein and b-lactoglobulin were found at the air interface. When emulsifiers were used, more fat was seen at the air interface, especially with unsaturated mono-glyceride. When whey protein isolate was used, fat globules were seldom found at the air interface, regardless of emulsifier presence. As the fat interface is formed

neutrophils increased from rest to recovery on d 42, with P increasing more ( $P = 0.04$ ). Percent neutrophils was increased on d 42, compared to d 0, with the greatest increase in P ( $P = 0.04$ ). Bee pollen supplementation, while not affecting measured fitness variables, may have a positive effect on performance by helping meet increased metabolic demands of equine athletes by increasing nutrient retention and feed intake.

**Key Words:** Pollen, Horse, Exercise

**80 Potassium supplementation affects plasma  $[K^+]$  during an 80 km endurance exercise test on the treadmill.** T. M. Hess\*<sup>1</sup>, K. Treiber<sup>1</sup>, D. S. Kronfeld<sup>1</sup>, J. N. Waldron<sup>2</sup>, C. A. Williams<sup>1</sup>, M. S. Freire<sup>1</sup>, A. M. G. B. Silva<sup>1</sup>, L. S. Gay<sup>1</sup>, D. A. Ward<sup>1</sup>, and P. A. Harris<sup>3</sup>, <sup>1</sup>Virginia Polytechnic Institute and State University, Blacksburg, <sup>2</sup>Rectortown Equine Center, Rectortown, VA, <sup>3</sup>Equine Studies Group, Waltham Centre for Pet Nutrition, Melton-Mowbray, UK.

During exercise plasma  $[K^+]$  increases and can lead to increased neuromuscular excitability and related clinical signs. Supplementation of K during exercise can further increase plasma  $[K^+]$ . A K-free electrolyte mixture (EM-K) was tested and compared to a K-rich mixture (EM+K) during an 80 km simulated endurance exercise test (EET) on a treadmill. Twelve horses were tested in a cross over design performing four bouts (B) of 20 km at 45% of their maximum heart rates with three 30-minutes of rest (R) between bouts. Before the start of EET and during each R horses were supplied with EM-K or EM+K. Blood samples were collected before (PRE), at 10 km of each B, at 20 minutes of every R and 10 minutes after B4 (REC) and analyzed for hematocrit (Hct), and plasma for pH,  $PCO_2$ , lactate ( $[La^-]$ ), phosphate ( $[PO_4^-]$ ), albumin (alb), CK and AST and electrolytes. Horses were weighed and electrocardiograms done at PRE, every R, and REC; weights were also measured in the morning after (MA) EET. Effects of stage (PRE, B1, B2, B3, B4, R1, R2, R3, R4, REC, MA) treatment (EM-K vs EM+K) and their interactions were evaluated by ANOVA in a mixed model with repeated measures. Body weight losses during EET increased up to 4.96% at REC, and were 2.3% below PRE at MA ( $P < 0.001$ ). Hct increased during B, returned to PRE at every R ( $P < 0.001$ ). Plasma alb increased during EET ( $P < 0.001$ ), returning to PRE values at REC. Plasma CK and AST increased progressively during EET ( $P < 0.001$ ). Plasma pH increased with exercise, decreased with R and REC ( $P < 0.001$ ). Plasma  $PCO_2$  and  $[Ca^{++}]$  decreased during exercise and increased during R periods, however  $[Ca^{++}]$  was lower than PRE at REC ( $P < 0.001$ ). Plasma  $[Mg^{++}]$  decreased initially with exercise, but then was higher than PRE at REC ( $P < 0.001$ ). Plasma  $[Na^+]$ ,  $[Cl^-]$ ,  $[La^-]$ , and  $PO_4^-$  increased progressively during the EET ( $P < 0.0001$ ). No abnormalities were observed on the EKG results. A treatment effect was found for plasma  $[K^+]$  ( $P = 0.014$ ), where horses that received EM-K had lower values than EM+K. Lower plasma  $[K^+]$  during exercise could help maintain resting membrane potential and prevent signs of neuromuscular hyperexcitability.

**Key Words:** Potassium, Equine, Exercise

first during ice cream processing, the composition of the air interface was found to be a direct consequence of the composition of the fat interface.

**Key Words:** Milk Proteins, Air Interface, Immuno-Labeling

**82 Evidence that the major novel disulfide bond in heated cows milk is between  $\beta$ -lactoglobulin Cys160 and  $\kappa$ -casein Cys88.** E. K. Lowe<sup>1</sup>, S. G. Anema<sup>1,2</sup>, M. J. Boland<sup>1</sup>, R. Jiménez-Flores<sup>3</sup>, and L. K. Creamer\*<sup>1</sup>, <sup>1</sup>Fonterra Research Centre, Palmerston North, New Zealand, <sup>2</sup>Riddet Centre, Massey University, Palmerston North, New Zealand, <sup>3</sup>Dairy Products Technology Center, California Polytechnic State University, San Luis Obispo.

Heat treatment of milk causes the milk proteins to interact irreversibly with one another, primarily caused by disulfide bond interchange. Early studies have shown that heating  $\beta$ -lactoglobulin (BLG) in solution invokes Cys-mediated disulfide bond interchange to give BLG polymers and BLG molecules with non-native disulfide bonds. Some of these molecules and polymers contain Cys66 or Cys160 in the reduced state.