

milk, -0.08 kg for fat, -0.12 kg for protein, -3.6 for dairy form, +2.2 for udder composite, +2.0 for body composite and +2.2 mo for productive life. Relative drop in protein and fat was lower than in milk. Heat tolerant bulls have daughters with lower milk production, lower water content in milk, larger body reserves, better udders and longer productive life. Heat stress effects may have been underestimated due to unequal quality of weather data. National genetic evaluation for heat tolerance is feasible.

Key Words: Heat Stress, Heat Tolerance, Test-Day Model

559 Reproduction data in USDA database. G. Wiggans*, *Animal Improvement Programs Laboratory, Agricultural Research Service, Beltsville, MD.*

The Animal Improvement Programs Laboratory began storing all breedings for cows and heifers in 2003. Some data back to 1997 also were stored. Reproduction data have been acquired for a high proportion of cows in recent years with most herds providing some data. Currently, two record processing centers supply breedings for heifers and up to nine types of reproductive events. The other centers supply the latest breeding each test day and pregnancy confirmation information for cows, but do not supply heifer data and additional reproductive events. Data from 2,336,621 calvings in 2003 and 304,183 heifers born in 2002 were analyzed to determine the portion of data with reproductive events reported. Usable service sire was reported for 89% of the breedings from the two centers with complete reporting, which had 53% of total breeding analyzed. Pregnancy confirmation was reported in 67% of the lactations, of these, 24% were confirmed not pregnant. Of the cows, 86% had at least 1 breeding reported and averaged 2.1 breedings. For heifers, the average number of breedings was 1.5 and breedings were reported for 82% of the heifers. Almost no estrus synchronization and very few cases of embryo transfer, either as a donor or recipient, have been reported. Of herds with 10 or more calvings, 70% had complete reporting and 24% more reported some breedings. Confirmations were reported for 81% of herds with 10 or more calvings. The reproduction data supports daughter pregnancy rate evaluations. For lactations without subsequent calving, pregnancy status is used to improve accuracy of estimates of days open. As pedigree information is added to the database, a calf's sire is checked against its dam's service sire and the provider notified when they differ. The calf's sire is not changed to the service sire because the service sire may be incorrect. This more extensive collection of reproduction information supports improved evaluations of daughter pregnancy rate, planned evaluation of male fertility and further research on fertility.

Key Words: Fertility, Days Open, Reproductive Events

560 Conception rates of Holsteins in New York and Georgia. C. Huang*, S. Tsuruta¹, I. Misztal¹, T. J. Lawlor², and J. S. Clay³, ¹University of Georgia, Athens, ²Holstein Association USA Inc., Brattleboro, VT, ³Dairy Records Management Systems, Raleigh, NC.

The objective of this study was to estimate fixed effects that influenced conception rate of Holsteins in NY and GA. Data were obtained from DRMS, Raleigh,

NC, and included production and service records on 417,910 cows in NY and 59,784 cows in GA from 2003 to 2004. After removing uncertainty and extreme records (without caving date or birth date, lactation ≥ 1 , days to service after calving ≥ 365 , service times ≤ 10 , and without next calving record), those numbers dropped to 146,821 cows in NY and 11,465 cows in GA, respectively. Using SAS PROC GLM, for each state, the model included the effects of days after calving group, lactation number, milk production level, AI status, caving month, service month, age of cow, herd, calving year and those interactions. In NY (GA), least squares means for conception rate, as a function of days postpartum was 0.51 (0.55) at 50 d and increased to 0.68 (0.74) at 250 d for AI sires. The conception rate was about 0.2 (0.12) higher for natural service sires than for AI sires. The conception rate was the highest at 0.68 (0.82) in March and the lowest at 0.51 (0.53) in June, and decreased by 0.05 (0.07) as milk production increased from 30 to 45 kg/day. The calving and insemination were very seasonal in GA, with 3 times more cows calving in October than in June. Also, the proportion of natural bull services was very seasonal peaking at 25% in summer and dropping to 15% in winter. Conception rate increased with days postpartum and natural service bulls had significantly higher conception rate. Also, it is influenced by season especially in Georgia.

Key Words: Conception Rate, Fertility, Holstein

561 Genetic parameters for conception rate and days open in Holsteins. S. Tsuruta*, C. Huang¹, I. Misztal¹, T. J. Lawlor², and J. S. Clay³, ¹University of Georgia, Athens, ²Holstein Association Inc., Brattleboro, VT, ³Dairy Records Management Systems, Raleigh, NC.

The goal of this study was to estimate genetic parameters for conception rate and days open in Holsteins. Data collected in NY from 2001 to 2003 were provided by the DRMS, Raleigh, NC. After editing, it included 89,271 first-parity service records for 43,344 cows. The first mixed linear model (bivariate analysis) was for conception rate at first service and for days open and included fixed effects of herd-year, age class, month of calving, AI status (natural service or AI), days to first service after calving (for conception rate only) and milk yield as a covariate, and random additive genetic and residual effects. Heritability estimates for conception rate at first service and days open were 1.4% and 2.5%, respectively. Genetic correlation between these traits was -0.92. The second model applied to conception rate with repeated records. It included the same fixed effects as the first model plus linear random regression as a function of days to service for the animal additive and permanent environmental effects. Heritability and repeatability estimates were 1.0-1.5% and 3.6-4.2%; they were approximately constant from 50 d to 250 d postpartum. The genetic correlations between the conception at 50 and (150, 250) d were 0.86 and 0.45, respectively. We also estimated genetic parameters for conception rate with threshold models as a binary trait. The heritability and repeatability estimates were about one and a half times higher than those from linear models. Days open is a good measure of fertility in NY. Conception rate may be a different trait at different days postpartum.

Key Words: Conception Rate, Heritability, Holstein

Companion Animals: Nutritional and Health Considerations for Companion Animals II

562 Effects of food and water intake on variation in ileal digesta viscosity among dogs fed a maintenance diet. C. Dikeman* and G. Fahey, Jr., *University of Illinois, Urbana.*

A two-period crossover design experiment was conducted to address effects of food and water intake on ileal digesta viscosity among dogs. Six ileal cannulated dogs, average weight of 26.0 kg (range, 19.5 to 29.6 kg), were fed during an initial 6-d adaptation phase up to individual energy requirements (ME = 145

kcal*kg BW^{0.67}). This phase preceded a 4-d collection of ileal digesta. The second 10-d period consisted of caloric/intake restriction by decreasing intake by one-half (ME = 72.5 kcal*kg BW^{0.67}). Dogs consumed an extruded diet that met or exceeded AAFCO recommendations for dogs at weight maintenance. Water was offered ad lib. Water intake was measured and recorded at 0800 and 2000 daily. Ileal digesta, for both periods, was collected for 1.5 h at 0900, 1300, and 1700 during the collection phase. Ileal digesta viscosity was measured, at multiple shear rates, using a Brookfield RV-DVII+ viscometer adapted with

vane spindle geometry. All viscosities exhibited shear-thinning behavior and are presented as area under the curve values (AUC). Data were analyzed using the mixed models procedure of SAS with a statistical model including the fixed effect of treatment and random effects of period and dog. In addition, linear regression analysis was used to determine the relationship between water intake and viscosity AUC. Daily water intake ranged from 310 to 1,159 ml. Food intake ranged from 137 to 186 g/d during the caloric restriction phase and 274 to 372 g/d when dogs consumed food to meet energy requirements. Digesta viscosity AUC values for dogs consuming food up to their energy requirement ranged from 6,978 to 59,866 cPRPM. Digesta viscosity AUC values for dogs during the caloric restriction phase ranged from 4,930 to 24,352 cPRPM. Viscosity AUC values were 39.6% ($P < 0.01$) lower when dogs consumed less food. Water intake did not account for variability in viscosity AUC, indicated an $R^2 = 0.07$. These results indicate that food intake accounts for greater variation in gastrointestinal tract viscosity than water intake.

Key Words: Viscosity, Ileal Digesta, Dog

563 Canine diet matrices affect digesta viscosity in vitro and ileal viscosity in vivo. C. Dikeman* and G. Fahey, Jr, *University of Illinois, Urbana.*

Two experiments were conducted to determine the effects of canine diet matrix on ileal digesta and simulated digesta viscosity in vitro. Three canned diets containing either carageenan (C), guar gum (G), or soybean hulls + cellulose (SBC), and three dry extruded diets containing rice bran (RB), wheat bran (WB), or soybean hulls (SB), were fed to 6 ileal cannulated dogs in a 6 x 6 Latin square design. Dogs were fed either 1400 or 400 g/d of canned or dry diet, respectively, such that caloric intake of canned and dry diets was similar. Ileal digesta was collected 3 times daily on the final 2 d of each 7-d period. In the second experiment, all diets were subjected to a two-stage in vitro gastric and small intestinal digestion simulation model. Viscosity of in vitro solutions was measured every 2 or 3 h during gastric and small intestinal simulations, respectively. Viscosity of digesta and in vitro solutions was measured, at multiple shear rates, using a Brookfield RV-DVII+ viscometer. All viscosities exhibited shear-thinning behavior and are presented as area under the curve values (AUC). Viscosity AUC of digesta ranged from 3,116 to 128,469 cPRPM, for canned C and SBC diets, respectively. Less variation in viscosity AUC was noted when dogs consumed dry diets (17,676 to 25,174 cPRPM, for WB and RB diets, respectively). Digesta viscosity for dogs consuming SBC was much higher ($P < 0.0001$) compared with all other dietary treatments. Digesta viscosity was lower ($P < 0.0001$) when dogs consumed C compared with SB, RB, WB, or SBC. Digesta viscosity for dogs consuming G was numerically lower than for the three dry diets. During gastric in vitro simulation, viscosity AUC at 0 and 6 h ranged from 189 to 331 cPRPM and 145 to 987 cPRPM for C and WB and G and WB diets, respectively. Small intestinal in vitro solutions at 0 and 18 h ranged from 91 to 410 cPRPM and 17 to 256 cPRPM for RB and G and G and SBC diets, respectively. With the exception of the SBC diet, consumption of canned diets resulted in lower ileal digesta viscosity compared with digesta following consumption of dry extruded diets in vivo and in vitro.

Key Words: Digesta, Viscosity, Dog

564 Effect of body size and diet on total dietary fiber digestibility in dogs. D. Hernot*¹, H. Dumon¹, V. Biourge², L. Martin¹, and P. Nguyen¹, ¹National Veterinary School, Nantes, France, ²Royal Canin Research Center, Aimargues, France.

We have previously reported that, fed a same dry diet, large and giant-breed dogs presented higher concentrations of fecal fermentation products and a higher digestibility of total dietary fiber (TDF) compared to small dogs. We have therefore hypothesized that large and small-breed dogs would have different fermentative capacity. The aim of the study was to test the effect of different dietary fiber contents on TDF digestibility in dogs varying in body size.

Twenty four dogs, varying from 4 to 59 kg body weight were used in the study: 6 Miniature Poodles (MP), 6 Standard Schnauzers (SS), 6 Giant Schnauzers

(GS) and 6 Great Danes (GD). All dogs were fed 4 diets differing in fiber amount and fermentable-to-non-fermentable ratio (F:nF). Diets 1, 2, 3 and 4 contained a F:nF of 0.15, 0.15, 0.36 and 0.48 with 7.7, 9.7, 8.9 and 9.2 % TDF, respectively. TDF was measured in diets and lyophilized feces using AOAC (1984) methods.

For each diet, we found a higher TDF digestibility in large dogs compared to small ones (from 41.9±2.9% for MP to 62.9±5.6% for GD, with control diet). For each breed TDF digestibility increased with the dietary F:nF ratio, except for diet 4 with which TDF digestibility was the lowest (from 40.7±9.1% for MP to 55.7±7.1% for GD). In the same way, digested dietary fiber amount increased with body size and dietary F:nF ratio except with diet 4. For each breed, we indeed found no difference in digested TDF amount between diet 3 and diet 4 (respectively, 9.82±1.48 and 9.95±0.99 g/day for GD).

We confirmed the higher TDF digestibility in large dogs and showed an effect of body size whatever the diet. Results of digested fiber amount suggested that dogs could adapt their fermentation process to an increase in dietary fermentable fiber until an upper limit was reached. With diet 4, which presented the highest fermentable fiber rate, fermentation capacity seems, indeed, to be overwhelmed. So, we could hypothesize that diet 3 still contained the highest fiber amount our dogs could ferment.

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Key Words: Dog, Dietary Fiber, Fiber Digestibility

565 Effect of body size and dietary fiber level on fecal bacterial mass and fecal quality in dogs. D. Hernot*¹, V. Biourge², H. Dumon¹, L. Martin¹, and P. Nguyen¹, ¹National Veterinary School, Nantes, France, ²Royal Canin Research Center, Aimargues, France.

Fed a same dry diet, large-breed dogs show higher fecal moisture and softer stools than small ones. We have reported a higher fermentation activity in large dogs. The aims of the study were 1/ to test the effect of different diets (varying in beet pulp and maize fiber content) on fecal bacterial mass and 2/ to determine whether diets and fecal bacterial mass correlated with fecal quality according to body size.

Dogs varying in body size were used in the study: 6 Miniature Poodles (MP), 6 Standard Schnauzers (SS), 6 Giant Schnauzers (GS) and 6 Great Danes (GD). All dogs were fed 4 diets differing in fiber amount and fermentable-to-non-fermentable ratio (F:nF). Diets 1, 2, 3 and 4 contained a F:nF of 0.15, 0.15, 0.36 and 0.48 with 7.7, 9.7, 8.9 and 9.2 % TDF, respectively. Fecal bacterial mass was estimated using diaminopimelic acid (DAPA) as a bacterial marker. Fecal moisture was measured and fecal consistency scored for two weeks.

For each diet large dogs presented a lower fecal consistency and higher fecal moisture than small ones. There was no effect of diet on fecal scores for MP and SS but diet 4 significantly decreased fecal scores in GS and GD (from 3.2i, ±0.3 with diet 1 to 3.0i, ±0.1 with diet 4, for GD). Neither diet nor body size had effect on fecal DAPA content. Including all dogs and diets, the mean fecal DAPA content was 0.49i, ±0.08 mg/g DM.

Beet pulp is known to induce well formed stools and also increase feces moisture. Those effects were confirmed in this study especially with diet 4 which contained the highest beet pulp rate and F:nF ratio. Nevertheless, while the effect of body size persisted for each diet on fecal consistency, results showed that large dogs would be more sensitive to a modification in dietary fiber level than small ones. The influence of dietary fiber on fecal consistency, in large dogs, did not seem to be the consequence of an increase in fecal biomass. More fermentation parameters have to be studied to confirm a more beneficial effect of fermentation on fecal consistency in large than in small dogs.

Acknowledgements: The authors thank Samuel Ninet and Gerald Pondevie for excellent technical assistance.

Key Words: Dog, Fecal Quality, Diaminopimelic Acid

566 Effects of selected concentrations of DL-methionine and 2-hydroxy-4-(methylthio)-butanoic acid on nitrogen balance and nutrient digestibility in growing dogs. I. Middelbos^{*1}, L. Karr-Lilienthal¹, J. Folador¹, M. Vazquez-Anon², G. Yi², and G. Fahey Jr.¹, ¹University of Illinois, Urbana, ²Novus International, Inc., St. Louis, MO.

The effects of DL-methionine (DLM) and 2-hydroxy-4-(methylthio)-butanoic acid (HMTBA; Alimet[®] Feed Supplement, Novus International, Inc.) on nitrogen balance and nutrient digestibility in growing dogs were evaluated. A basal diet (control) containing commercially available ingredients was formulated to contain minimal concentrations of methionine (0.4% of DM). Batches of basal diet were supplemented with 0.1 or 0.2% DLM or HMTBA. Thirty Pointer puppies (age = 72 ± 6 d; BW = 5.5 ± 1.0 kg) were assigned to one of the five diets for 15 d, using three blocks of ten puppies each. Dogs were fed 90% of the voluntary feed intake of the lowest consumer within treatment and block prior to collection. Total feces and urine were collected for 5 d. Contrasts were used to compare DLM vs. HMTBA and inclusion levels. Nitrogen balance did not differ between methionine sources or inclusion levels. Fat and total dietary fiber (TDF) digestibilities were not affected by methionine source or inclusion level, but variation in TDF concentration among diets led to higher TDF intake ($P < 0.05$) of diets supplemented with HMTBA. Higher TDF intake coincided with higher fecal TDF output ($P < 0.05$) and lower ($P < 0.05$) digestibilities for DM, OM, CP, and energy for diets supplemented with HMTBA. These data suggest no effect of inclusion level or methionine source on nitrogen balance in growing dogs. TDF concentration discrepancies among the diets have impacted nutrient digestibilities in this study.

Key Words: Dog, Methionine, Nitrogen Balance

567 Encapsulation to deliver a steady-state level of dietary lutein to an animal via dry pet food. L. Deffenbaugh^{*}, Kemin Industries, Inc., Des Moines, IA.

Lutein is one of numerous carotenoids with potential health benefits for companion animals. Natural sources include green leafy vegetables, marigolds, and maize, in which lutein is present as a fatty acid ester. The lutein esters are commercially obtained via a solvent extraction process from marigolds and are commonly used as a pigmenter in poultry diets. Saponified (un-esterified) lutein exists in animal tissues and may play a beneficial role in eye and immune health for companion animals. A purified (>90%) source of free lutein is a promising functional ingredient for pet food, but, like most biological antioxidants, is difficult to deliver via the convenience of a dry diet because of poor stability. Unprotected lutein added to a petfood diet will lose >50% of its activity through the manufacturing process, and then deplete to <20% of the initial inclusion level within the first few months of shelf life. An encapsulation process has been developed that protects lutein through processing and shelf life, yet allows for bioavailability to the animal upon ingestion of the diet. Three extrusion tests have shown that >90% of encapsulated lutein survives the process. Shelf life studies further show that the encapsulated lutein survives up to two years in the diet with minimal (<10%) additional loss. Encapsulation of lutein allows for a guaranteed level of lutein to be delivered in a dry petfood diet throughout the shelf life of the diet. Consequently, a steady-state level of lutein will be ingested and absorbed by an animal absorbing the diet. The cost of delivering a biologically active level of lutein in a dry petfood diet has been optimized to be comparable to other "value-added" ingredients such as natural antioxidants and palatants. Further, this encapsulation matrix will also likely be viable for hosting other biological nutrients that are unstable in an unprotected form.

Key Words: Lutein, Encapsulation, Biological Antioxidants

568 Effect of rosemary extract ingestion on canine serum antioxidant levels. W. Gamble^{*}, Kemin Nutrurance, Des Moines, IA.

Because free radicals cause damage to cell walls, certain cell structures, and genetic material within cells, oxidative stress may play a role in diseases. Anti-

oxidants work by binding to free radicals, transforming them into non-damaging compounds, or repairing cellular damage. Antioxidants can be important in maintaining immune responses and vaccine recognition in young cats and dogs and can counter-act decreases in immune-cell function for older animals. Therefore, it has been proposed that health might be improved by increased dietary intake of antioxidants. Plant derived antioxidants, such as rosemary extracts, have been proposed as dietary antioxidants. Phenolic diterpene antioxidants, such as carnosic acid, carnosol, rosmanol, and galdosol have been isolated from rosemary with carnosic acid present in the greatest abundance. For these reasons the effect of rosemary extract on the immune system of companion animals is of interest. In order to demonstrate an effect on immune system, it is necessary to first demonstrate bioavailability of the active antioxidant molecules. A bolus canine feeding study was undertaken with 6 dogs using partially a purified rosemary extract at 10 mg carnosic acid/kg body weight. Serum samples were drawn over a time course of one to six hours post-dosing. These samples were analyzed for carnosic acid content directly by Liquid Chromatography/Mass Spectrometry and by a Malondialdehyde assay method to measure lipid peroxidation as an indicator of serum antioxidant status. The Liquid Chromatography/Mass Spectrometry results demonstrated the absorption of carnosic acid into the bloodstream with peak concentrations occurring from one to three hours post-dosing. The Malondialdehyde assay results were not as consistent, showing much more dog to dog variation. However, the Malondialdehyde assay results for each dog did exhibit consistency when a second feeding study was performed.

Key Words: Antioxidant, Rosemary, Serum

569 A multi-center clinical study of the effect of docosahexanoic acid (DHA) on joint inflammation and mobility in dogs with mild to moderate osteoarthritis. F. Buonomo^{*1}, D. Grohs¹, M. Conzemius², S. Johnston³, and D. Millis⁴, ¹Monsanto Company, Animal Science Division, St. Louis, MO, ²Iowa State University, Ames, ³VA-MD Regional College of Veterinary Medicine, Blacksburg, VA, ⁴University of Tennessee, Knoxville.

DHA is a 22-carbon highly unsaturated derivative of α -linolenic acid and a member of the omega-3 family of essential fatty acids. Dietary DHA supplementation has been hypothesized to reduce the production of proinflammatory 2-series prostaglandins and 4-series leukotrienes, and increase the production of the less inflammatory 3-series prostaglandins and 5-series leukotrienes. The objective of this study was to determine if dietary DHA supplementation improves clinical lameness and range of motion assessments in dogs with mild to moderate osteoarthritis. This study included 35 client-owned dogs diagnosed with mild to moderate arthritis in at least one elbow, hip, or stifle joint according to a defined clinical scale provided to trained clinicians. Dogs were randomly assigned to a placebo (18 dogs) or DHA (17 dogs) treatment group. Alginate pellets containing 0 or 900mg DHA were administered orally once daily for 84 d. Clinical assessment scoring included determinations of lameness, weight-bearing status, joint mobility, pain and radiography. These were collected at two pretreatment time points, and on d 28, 56, and 84 of treatment. Kinetic gait evaluation was conducted on a subset of dogs (8 placebo, 7 DHA) at the same time points. Client efficacy evaluations were conducted weekly throughout the study. Blood and synovial fluid samples were collected for analysis of prostaglandin E₂, leukotriene B₄, osteocalcin, IGF-I and IGFBP-5. Dogs receiving DHA had significantly improved lameness, range of motion, subjective investigator efficacy and client efficacy scores. Kinetic gait evaluation indicated a significant improvement in peak vertical impulse in dogs with affected forelimbs following several weeks of DHA administration. Dogs receiving DHA had significantly lower circulating levels of PGE₂ and LTB₄, but significantly higher levels of IGF-I, IGFBP-5, and osteocalcin, as compared to those receiving the placebo. These data indicate that DHA supplementation may be beneficial in ameliorating aspects of osteoarthritis development in dogs.

Key Words: Docosahexanoic acid, Osteoarthritis, Canine