285 Protein quality differences exist among high quality mammalian, avian, and marine protein sources evaluated using avian assays. T. A. Faber*[1], D. C. Hernot[1], C. M. Parsons[1], K. S. Swanson[1], S. Smiley[2], P. J. Bechtel[2,3], and G. C. Fahey, Jr.[1], [1]*University of Illinois, Urbana*, [2]*University of Alaska, Fairbanks, Alaska*, [3]*Agricultural Research Service, Fairbanks, Alaska*.

Meat and fish serve as important protein sources in the human and companion animal diet, but limited information is available on quality differences among high quality protein sources. Beef loin, pork loin, chicken breast, pollock fillet, and salmon fillet were evaluated for protein quality and amino acid bioavailability using the cecectomized rooster and protein efficiency ratio (PER) assays. Pollock contained the highest concentration of protein, total essential amino acids (TEAA), and total non-essential amino acids (TNEAA; 96.9, 38.6, and 50.3%, respectively, dry matter basis). Salmon contained the next highest concentrations (92.8, 36.4, and 44.6%) followed by chicken (90.3, 36.1, and 43.2%). Beef had the lowest protein content (82.7%), but higher TEAA and TNEAA (33.9 and 42.0%) than pork (86.2, 33.6, and 41.3%). Twenty cecectomized roosters were crop-intubated and dosed with one of the five test protein substrates. All excreta were collected, freeze-dried, and analyzed for amino acids. Amino acids in pollock fillet were more digestible (90.4%) ($P<0.05$) compared to other test substrates, whereas chicken breast and salmon fillet had the lowest ($P<0.05$) amino acid digestibility (86.9 and 87.5%, respectively). Protein efficiency ratio was evaluated using one hundred 8-d old male chicks fed one of five diets containing 10% protein provided by each of the five test protein substrates. The assay was conducted as a completely randomized design: five treatments with five chicks per treatment and each treatment with four replicated pens. No differences were noted for beef loin, pork loin, salmon fillet, or pollock fillet; however, chicken breast had a lower ($P<0.05$) PER than other substrates. Among test protein sources, pollock fillet was the highest quality substrate and chicken breast the lowest based on standardized amino acid digestibility and PER data.

Key Words: amino acid bioavailability, protein quality, meat

286 Total tract nutrient digestibility, fecal characteristics, and blood chemistry profiles of dogs as affected by alpha-cyclodextrin supplementation. M. A. Guevara*[1], K. A. Garleb[2], and G. C. Fahey[1], [1]*University of Illinois, Urbana*, [2]*Abbott Nutrition, Columbus, OH*.

The objective was to examine nutrient digestibility, fecal characteristics and blood chemistry profiles of dogs as affected by alpha-cyclodextrin (ACD) supplementation. Five mixed-breed hounds were used in a Latin square design with 5 periods of 14 d each, including 10 d for diet adaptation and 4 d for fecal collection. Dogs were fed twice a day a diet with poultry by-product meal and brewer's rice as the main ingredients, and chromic oxide (0.2%) was included as a digestion marker. Dogs were supplemented with either 0, 1, 2, 3, or 4 g of ACD diluted in 15 ml of water twice per day for a total of 0, 2, 4, 6, and 8 g of ACD per day. Average daily food intake, fecal production on a dry matter basis, fecal scores, and dry matter digestibility were not significantly different among treatments. Body weight and condition score, and blood triglycerides and cholesterol concentrations, remained unaltered throughout the duration of the experiment. Crude protein, and fat digestibility coefficients were lower ($p<0.05$) for treatment groups receiving 6 and 8 g of ACD compared to control. Alpha-cyclodextrin lowered fat and crude protein digestibility somewhat without affecting blood lipid concentrations or outcomes related to tolerance.

Key Words: dog, alpha-cyclodextrin, digestibility

287 Influence of dietary protein on fecal quality and colonic tight junction gene expression in Miniature poodles and German shepherds. J. Nery*[1,2], V. Leray[1], V. Biourge[3], L. Martin[1], H. Dumon[1], and P. Nguyen[1], [1]*École Nationale Vétérinaire de Nantes, France*, [2]*University of Turin, Italy*, [3]*Royal Canin, Aimargues, France*.

Large dogs are prone to producing feces of poorer quality than small dogs, partly due to a higher colonic permeability. Fermentation of undigested proteins would have deleterious effects on the colonic mucosa. The aim of the study was to assess the effect of dietary protein source and level on fecal quality and tight junction (TJ) proteins in the colon of small and large dogs. Five Miniature poodles (MP) and 6 German shepherds (GS) spayed dogs were fed 2 diets varying in main protein sources (wheat gluten: WG, and poultry meal: PM) and levels (LP: 21.4%, and HP: 34.8% CP as fed) in a 2x2 wk cross-over study design. Feces were scored daily (1=dry and hard to 5=liquid). Proximal and distal colonic biopsies were taken at the end of each 14-d period. mRNA expression of claudins 4 and 7 (CLN4 and CLN7), junctional adhesion molecule (JAM), occludin (OCLD) and zonula occludens 1 and 2 (ZO-1 and ZO-2) were measured by real time-PCR. Fecal score data was analyzed using Kruskal-Wallis test and gene expression using repeated-measures ANOVA. Fecal score was higher in GS dogs ($p<0.001$ for diet WG-LP, $p=0.006$ for PM-HP), and when feeding PM-HP ($p=0.010$ for MP, $p=0.003$ for GS). Protein digestibility was WG: 87.9% and PM: 83.4% ($p<0.001$). The expression of CLN4 and ZO-2 in the proximal colon was higher ($p=0.008$ and $p=0.088$) in GS than MP dogs. Higher expression of CLN7 was observed ($p=0.059$ in the proximal and $p=0.069$ in the distal colon) of GS than MP. The expression of OCLD was higher in GS than MP, in the proximal and distal colon ($p=0.002$ and $p=0.058$, respectively) and when feeding WG-LP and PM-HP ($p=0.046$ and $p=0.013$, respectively). No effects of diet, breed or biopsy location were found for JAM and ZO-1. Feeding highly digestible protein source WG at low level leads to an improvement of fecal score and moisture but it does not influence colonic TJ expression. Poorer fecal score in GS compared with MP would not be related to lower TJ expression in the colon of GS dogs.

Key Words: dog, protein, tight junction

288 Identifying relationships of urinary 5-hydroxyindoleacetic acid, homovanillic acid and cortisol with behavioural display during social isolation in the domestic dog. M. J. Toscano*, C. Basse, E. Blackwell, J. W. S. Bradshaw, and R. Casey, *DFAS, University of Bristol, Langford, UK*.

Separation related behaviour (SRB) of domestic dogs is a leading cause for returning dogs to shelters. The current effort served to develop a test to predict SRB using behavioural and physiological measures. Before testing, 52 shelter dogs were habituated to a single experimenter on a single day for 20 min. On the following day, urine was passively taken for the quantification of 5-hydroxyindoleacetic acid (5-HIAA), homovanillic acid (HVA), cortisol and creatinine. Creatinine was used as a corrective factor for the other physiological measurements. Following urine collection, the experimenter spent between one and 12 minutes with the animal and then left the room for five minutes. All interactions on the second day between the experimenter and dog as well as the dog in isolation were recorded on a video recorder and then analyzed for the occurrence of various behaviours that had been found in previous research to be predictive of SRB. Urine was analyzed for 5-HIAA and HVA using HPLC while a radioimmunoassay was used for cortisol and

creatinine. Linear regression was used to identify correlations between cortisol and neurotransmitter metabolites and SRB related behaviours. Neither 5-HIAA nor DOPA proved to be predictive of either the duration or latency to show SRB ($P > 0.1$). However, cortisol showed a weak positive correlation with the total duration of SRB shown (vocalisation and destruction combined; Pearson $r = 0.401$, $P<0.05$). The metabolites 5-HIAA and HVA displayed a weak positive correlation with the duration for which dogs remained standing at the door with a tense body posture (5-HIAA: Pearson $r = 0.383$, $P=0.05$; HVA: Pearson $r= 0.321$, $P=0.02$). Both also negatively correlated with the duration of interaction with the tester before being left alone (5-HIAA Pearson $r = -0.328$, $P=0.018$; HVA: Pearson $r = -0.278$, $P=0.046$). Our findings indicate a potential relationship between cortisol and neurotransmitter metabolites, and the manner in which domestic dogs respond to an anxiogenic situation, although more work is needed to identify the mechanisms of these correlations

Key Words: shelter, dog, 5-HIAA

289 Canine adipose tissue transcriptome changes following eight weeks of diet-induced obesity. R. W. Grant*, B. M. Vester, T. K. Ridge, T. K. Graves, and K. S. Swanson, *University of Illinois*, *Urbana*.

Changes that occur in organs and tissues over the course of obesity development are not well characterized. The purpose of this study was to characterize adipose tissue transcriptome changes occurring after 8 wk of diet-induced obesity and compare these changes to circulating metabolites. Intact female beagles were fed a commercially available high-fat diet and randomized to either ad libitum feeding (n=5) or weight maintenance (n=4). Subcutaneous adipose tissue biopsies and blood samples were collected at baseline and at 8 wk. At least .3g of subcutaneous adipose was collected after an incision was made over the latissimus dorsi and immediately frozen in liquid nitrogen. Total cellular RNA was extracted using Trizol. Transcriptome changes were assessed using Affymetrix Canine 2.0 microarrays and analyzed using the Limma package with an FDR = 0.05. After 8 wk, body fat mass (obese: 4.16±.15kg vs control:1.62±.08kg), BW, and blood leptin were elevated ($P<0.05$) in dogs fed ad libitum, but blood NEFA, triglyceride, insulin, glucose, adiponectin, CRP, and TNF-α concentrations were unchanged. 790 gene transcripts were differentially expressed in adipose tissue following 8 wk of diet-induced obesity. The majority of these changes were observed in seven functional classes: transcription/translation, metabolism, apoptosis/cell cycle regulation, transport, RNA/DNA processing, signaling and redox state. These results indicate that major changes associated with cell growth and metabolism occur during diet-induced obesity and adipocyte growth and proliferation prior to the onset of systemic low-grade inflammation.

Key Words: obesity, adipose, transcriptomics

290 Colonic protein metabolites and microbial populations are altered in adult cats by consumption of cellulose, fructooligosaccharides, or pectin. K. A. Barry*, B. J. Wojcicki, I. S. Middelbos, B. M. Vester, K. S. Swanson, and G. C. Fahey Jr., *University of Illinois*, *Urbana*.

Twelve young adult (1.5 y) male cats were used in a replicated 3 × 3 Latin square design to determine the effects of fiber type on nutrient digestibility, fermentative end-products, and microbial populations in feces. Three diets containing 4% cellulose, fructooligosaccharides (Synergy C, Beneo-Group, Tienen, Belgium; FOS), or pectin were evaluated. Nutrient digestibility; fecal output, pH, score, and fermentative end-products; and microbial populations were measured. No differences were observed in intake of dry matter (DM), organic matter (OM), or crude protein; DM digestibility; OM digestibility; or fecal output, pH, or concentrations of phenylalanine or histamine. Crude protein digestibility decreased ($P < 0.05$) in response to supplementation with pectin vs. cellulose. Both FOS and pectin supplementation resulted in higher ($P < 0.05$) fecal scores and concentrations of ammonia, butyrate, isobutyrate, isovalerate, valerate, total branched-chain fatty acids, phenol, tryptamine, and cadaverine. While fecal concentrations of putrescine and total biogenic amines increased ($P < 0.05$) with both FOS and pectin, the concentrations of these compounds were greater in cats supplemented with pectin than FOS. Fecal indole concentrations and Bifidobacterium spp. populations increased ($P < 0.05$), while tyramine concentrations and E. coli populations decreased ($P < 0.05$), in FOS-supplemented cats. Fecal concentrations of acetate, propionate, total short-chain fatty acids, and spermidine increased ($P < 0.05$) in pectin-supplemented cats. Fecal concentrations of Clostridium perfringens, E. coli, and Lactobacillus spp. also increased ($P < 0.05$) in pectin-supplemented cats. Despite increasing populations of protein-fermenting microbiota, pectin increased fermentative end-products associated with carbohydrate vs. protein fermentation. Pectin and FOS may be useful fiber sources in promoting intestinal health of the cat.

Key Words: cat, fiber, protein metabolites

291 Apparent macronutrient digestibility of four raw meat diets in African wildcats, jaguars, and Malayan tigers. K. R. Kerr*[1], A. Beloshpaka[1], C. Dikeman[2], S. Burke[2], L. G. Simmons[2], and K. S. Swanson[1], [1]*University of Illinois*, *Urbana*, [2]*Henry Doorly Zoo*, *Omaha, NE*.

Captive exotic felids in the US are traditionally fed horse-based raw meat diets, while those in the UK are usually fed beef–based diets. Little nutritional or metabolic information has been collected from captive exotic cats fed raw diets, and most have focused on horsemeat and beef-based diets with no attention paid to commercially available alternatives. With the closing of horse abattoirs in 2007, the availability of quality grade horsemeat for use in zoological institutions in the US has decreased, and there is a need for research on possible alternatives. The objective of this study was to evaluate the differences in apparent digestibility of four raw meat-based diets. Diets based on beef (BE), bison (BI), elk (E), and horse (H) meats were fed to three captive exotic felid species: African wildcats (AWC), jaguars (JAG), and Malayan tigers (MT). Four animals of each species were randomized to treatment individually. In general, the diets tested were highly digestible in all species. Apparent dry matter (DM) and organic matter (OM) digestibilities were lower ($P<0.05$) in cats fed BI (DM = 82.7%; OM = 85.5%) as compared to those fed BE (DM = 87.9%; OM = 90.3%) and E (DM = 86.9%; OM = 89.6%), and lower ($P<0.05$) for cats fed H (DM = 84.5%; OM = 87.4%) as compared to those fed BE. Apparent fat digestibility was lower ($P<0.05$) in cats fed E (87.9%) as compared to those fed BE (94.6%) and H (93.4%), and lower ($P<0.05$) for cats fed BI (90.2%) as compared to those fed BE. To conclude, our results suggest that all protein sources are highly digestible and may be suitable replacements for horse meat.

Key Words: digestiblity, feline

292 Response of the somatotropic axis and growth rate in mule deer (*Odocoileus hemionus*) fed three different diets from birth to 68 weeks of age. G. A. Comeau*[1], S. McCusker[2], J. P. Richmond[1], L. A. Shipley[2], E. A. Koutsos[3], and S. A. Zinn[1], [1]*University of Connecticut, Storrs*, [2]*Washington State University, Pullman*, [3]*Mazuri Exotic Animal Nutrition, St. Louis, MO*.

To examine the somatotropic axis in mule deer fed 3 distinct diets from birth (June) to 68 wk of age, mule deer (n=24) were randomly assigned to 1 of 3 dietary treatments [3 males (M); 5 females (F)/group). Before weaning (15 wk), animals were fed milk replacer and their experimental diet. Diets differed in starch and fiber [A: high starch (22%), low fiber (13%); B: medium starch (16%), medium fiber (15%); and C: low starch (3%), high fiber (29%); DM basis]. Animals were exposed to natural photoperiods. Blood samples and BW were taken at 0, 5, 15, 24, 33, 47, 58, 68 wk. From 24 to 68 wk, leg length, and loin (LT) and rump fat (RFT) thickness were measured. Plasma GH and IGF-I were determined using RIA and IGFBP-2 and -3 were quantified using ligand blot. Except for IGFBP-2, diet did not influence any variables measured and data were combined. Average BW increased (P<0.01) from birth (7.3±1.2 kg) to 68 wk (66.4±1.1 kg) and was greater (P<0.01) in M than F (36.2±1.2 vs. 30.5 ±0.9 kg). Leg length (42.8 to 48.5±0.3 cm) and LT (2.8 to 3.7±0.07 cm) increased (P<0.01) from 24 to 68 wk and were greater (P<0.01) in M than F (47.1 vs. 44.5±0.3 cm, 3.4 vs. 3.0±0.1 cm, respectively). Measures of RFT decreased (P>0.01) from 24 to 47 wk (0.5±0.06 to 0.05 ±0.07 cm) and then increased (P<0.01) until 68 wk (1.5±0.1 cm). In addition, RFT tended to be greater (P<0.09) in M than F (0.53 vs. 0.38±0.05 cm). Concentrations of GH decreased (P=0.01) from birth (9.4±1.7 ng/mL) to 68 wk (1.7±1.4 ng/mL). Plasma IGFBP-2 paralleled changes in GH, except IGFBP-2 was greater (P = 0.05) in fawns fed Diet A. From birth to 33 wk IGF-I declined (112 to 63±9.4 ng/mL; P<0.01), and then gradually increased (P<0.01) until 68 wk (133±9.4 ng/mL). Overall IGF-I was greater in M than F (135±7.7 vs 98±4.3 ng/mL). Concentrations of IGFBP-3 paralleled IGF-I. Developmental patterns of GH and IGFBP-2 are similar to domestic cattle, but the decline in IGF-I and IGFBP-3 from birth to 33 wk may indicate that season influences these hormones in mule deer.

Key Words: mule deer, somatotropic axis, insulin-like growth factor-I

293 Effects of zinc amino acid complex and iron amino acid complex on performance, health and pelt quality of weanling blue fox (*Alopex lagopus*). Y. Zhang[1], H. Wei[1], D. J. Tomlinson*[2], and T. L. Ward[2], [1]*Institute of Special Wild Animal and Plant Science, Jilin, China*, [2]*Zinpro Corporation, Eden Prairie, MN*.

Healthy 65-day old arctic blue foxes (60 male and 60 female) with similar body weight and near kinship were assigned randomly to one of four treatments with 30 replicates. Treatment diets were: (1) Control: 80ppm supplemental Zn from ZnSO4; (2) 40ppm Zn from ZnSO4+40ppm Zn from Availa-Zn zinc amino acid complex (AvZn) ; (3) 80ppm Zn from AvZn; (4) diet 2 +40ppm Fe from Availa-Fe iron amino acid complex (AvFe). Diets were similar in ingredient composition except for trace mineral supplement. Diets were offered in two phases: growth (0 to 60d) and pelting (61 to 147d). Foxes were fed and managed in individual cages. Body weight and size were recorded every two wk. Ten kits were sacrificed at the beginning of the study to establish liver trace mineral status. Blood was collected from 24 foxes per treatment at the beginning and end of the study to measure superoxide dismutase and lactate dehydrogenase activity. At the end of the study, liver samples were collected from 24 fox per treatment to determine trace mineral status. Pelt quality was assessed for length, width and total area. Fur quality was assessed for texture, uniformity, color, clarity, length and density. Results show that compared to inorganic zinc, supplementing with AvZn at 40 or 80ppm Zn resulted in greater weight gain (P < 0.05) and feed intake (P < 0.05); longer body length at 80 ppm AvZn (P < 0.05); better fur quality (skin length, width and area with AvZn at 80 ppm; length and amount of guard hair and fluff, and fur density – all AvZn treatments; P < 0.05); and higher scores in sensory assessment - all AvZn treatments; significant increase in liver zinc concentration at 80 ppm AvZn (P < 0.01); greater maintenance of serum SOD and LDH activity which increased with level of AvZn in diet. These findings indicate supplementing arctic blue fox with AvailZn and AvailFe had positive effects on growth, fur quality and sensory effects.

Key Words: fox, zinc amino acid complex, iron amino acid complex

CSAS Symposium: Nutrition – Behavior Interaction in Ruminants

294 Behavior and dairy cattle nutrition: Not just what she eats but how she eats it. M. A. G. von Keyserlingk* and D. M. Weary, *University of British Columbia, Vancouver, BC, Canada*.

One of the most important challenges that any animal faces is ensuring its daily food supply. In intensive dairy cattle production, cows are completely reliant on our ability and knowledge to provide them with food that supports growth, productivity, health and welfare. There has been great progress in the field of dairy cattle nutrition over the past years – we are now better able to estimate the dietary needs of dairy cattle, and meet these needs through carefully formulated diets. Research on behavior is now broadening our understanding of dairy cattle nutrition; the question is no longer just what do they eat, but how do they eat it, and this improved understanding of behavior is helping to avoid practical problems such as competition for feed. One of the main challenges for lactating dairy cows is a sudden increase in nutrient requirements to support the onset of lactation at a time when dry matter intake lags behind. Cows are also susceptible to a suite of diseases in these weeks immediately after parturition. Thus, a more sensitive method of continuously monitoring animal health or risk for disease during the transition period is needed. Recent work in our laboratory indicates that changes in feeding behavior and dry matter intake in the weeks before calving are valuable indicators of illness in dairy cows. An understanding of social behavior in cattle can help improve feed access and changes in these behaviours also can be used as an early indicator of ill health.

Key Words: behavior, nutrition, dairy cattle

295 Interactions of nutrition and behavior in dairy calves. J. K. Drackley*, *University of Illinois, Urbana*.

Raising dairy calves has too often been viewed as a nuisance on dairy farms rather than as a critical investment for the future of the business. That calves have remarkable growth potential in early life has been well-documented for decades, yet has been forgotten amid the convention of restricted calf feeding. Recent research has confirmed this unexploited growth potential and also demonstrated that improved early nutrition increases subsequent milk yield. These findings have resulted in widespread interest in early-life nutrition in calves, and how to provide it in practical on-farm systems. While behavioral research in calves has frequently been relegated by nutritionists to the category of