growth or in response to cold stress. From the present results it appears that, in comparison to leghorns (resistant to heart failure), fast growing broilers (susceptible to heart failure) in general have lower cardiac energy reserve.

Key Words: broiler, energy metabolism, heart failure and ascites

395 Investigation of Proton Conductance in Liver Mitochondria of Broilers with Pulmonary Hypertension Syndrome (PHS). D. Cawthon*, M. Iqbal, J. Brand, and W. Bottje, *Department of Poultry Science, Univ. of Arkansas, Fayetteville AR 72701.*

We have observed mitochondrial dysfunction associated with PHS in broilers that includes increased oxygen radical production. Proton leak or conductance (the futile cycling of protons across the inner mitochondrial membrane) can account for at least 20% of mitochondrial O_2 consumption. The objective of this study was to determine if proton conductance differs in Control and PHS liver mitochondria. Liver mitochondria were isolated from broilers with PHS and from healthy Controls. PHS mitochondria had a lower respiratory control ratio than did Controls. Membrane potential and O_2 consumption were determined simultaneously by monitoring the distribution of the lipophillic cation (triphenylmethylphosphonium [TPMP]) with an ion-sensitive electrode and a Clark electrode, respectively (see Brand, 1995. Ch. 3 Bioenergetics IRL Press, Oxford). Mitochondria were treated with nigericin to dissipate the H+ gradient to enable membrane potential to be determined without concomitant changes in H+ concentration across the membrane. Proton conductance was assessed by following changes in TPMP+ as state 4 respiration was slowed with sequential additions of malonate. The results indicated that at any particular high membrane potential, the PHS mitochondria respired more slowly than Controls. This is the classic demonstration of a lower proton conductance in PHS mitochondria. The lower proton conductance may account for the increased oxygen radical production we have previously observed in PHS mitochondria. These findings help define the nature of mitochondrial dysfunction in broilers with PHS. (Supported by USDA-NRI #99-02123 to W. Bottje.)

Key Words: Pulmonary Hypertension Syndrome, Liver Mitochondria, Proton Conductance

396 Tissue and Mitochondrial Antioxidant Enzyme Activites in Broilers with Pulmonary Hypertension Syndrome (PHS). M. Iqbal*, D. Cawthon, R. Wideman, Jr., and W. Bottje, *Department of Poultry Science, Univ. of Arkansas, Fayetteville, AR 72701.*

Oxidative stress plays a role in the etiology of PHS in broilers. The objectives of this study were to determine if antioxidant enzyme activities a) are altered by PHS and/or high dietary vitamin E (VE), and b) differ in broilers genetically selected (S) or not selected (NS) for PHS resistance. In these studies, broilers were raised in cold temperatures to induce PHS. In Exp. 1, broilers were fed diets with 15 and 100 IUα-tocopherol (VE) per kg. Enzyme activities were determined spectrophotometrically using established procedures that were adapted for microtiter plate analyses. In Exp. 1, PHS lung mitochondria exhibited oxidative stress (lower α-tocopherol, reduced glutathione [GSH] and higher oxidized [GSSG] to reduced GSH ratio) that was associated with higher GSH peroxidase (GSHPx) and lower GSH reductase (GSHRed) activities compared to Controls. Liver γ-glutamyl cysteine synthetase (gGCS), the rate limiting enzyme in GSH synthesis was unaffected by PHS or high VE. In liver, high dietary VE lowered GSHPx but had no effect on GSHRed or gGCS activities. In Exp. 2, GSHPx activity was higher and GSHRed lower in lung mitochondria obtained from NS compared to S broilers. The lower GSHRed activity corresponded to a higher GSSG/GSH ratio. Whereas there was no differences in liver GSHPx and GSHRed activities, liver gGCS activity was lower in livers obtained from NS compared to S broilers. The results indicate that activities of antioxidant enzymes are altered by PHS, presumably in response to the oxidative stress present in these birds. Modulation of antioxidant activities by high VE was observed in liver tissue. Higher gGCS in the liver birds genetically resistant to PHS could be important in overall antioxidant status of these birds. (Supported by USDA-NRI #99-02123 to W. Bottje.)

Key Words: Pulmonary Hypertension Syndrome, Antioxidant Enzymes, Broilers

397 Effects of dietary sodium chloride, sodium sesquicarbonate, or ammonium chloride, in various combinations and levels, on ascites susceptibility of young broiler chickens in a cool environment at simulated high altitude (17% oxygen). R. G. Teeter*[1], J. H. Swartzlander[1], A. Beker[1], D. M. Hooge[2], and K. R. Cummings, [1]*Oklahoma State University, Stillwater, OK,* [2]*Hooge Consulting Service, Inc., Eagle Mountain, UT,* [3]*Church & Dwight Company, Inc., Princeton, NJ.*

Day old, vaccinated Cobb 500 chicks were evaluated in two metabolic chamber studies, 240 chicks per trial (24 chambers of 10 birds each), to 21 days old under moderate cool stress and 17% oxygen atmosphere (nitrogen administration). Ten practical corn-soy-meat blend diets were formulated to contain various levels of sodium chloride (NaCl) or sodium sesquicarbonate (SS; 30.4% Na) singly, or in combination, or ammonium chloride (AC; 66% Cl) and SS in place of NaCl. The SS has equimolar Na bicarbonate and Na carbonate. Analyzed Na levels were 0.19, 0.28, and 0.37% in combinations with Cl levels of 0.11, 0.25, and 0.39% (from previous regular pen trial, using same basal diet, in which 0.23% NaCl + 0.3% SS gave best broiler results with ionophore, coccidial challenge, and built-up litter; see Hooge *et al.*, 2001, IPSF abstract 14, Atlanta). Dietary electrolyte balances, Na+K-Cl in mEq/100 g, ranged from 20.8 to 36.5. Significance was at $P<0.05$ using a completely randomized design. Body weights overall were below industry norms due to oxygen deficiency. The SS treatments without NaCl appeared deficient in Cl; for example, the 0.3% SS diet with 0.19% Na and 0.11% Cl was lower in body weight at wk 1 and 2 than all or most other treatments, but adapted somewhat by wk 3. Heaviest 3 wk body weight was with 0.46% NaCl and lightest was with 0.23% NaCl + 0.3% SS. No differences in feed conversion ratio were detected. Right venticle weight and ascites heart index (right ventricle/total heart) were not affected, but ascites score (0=least to 3=most severe; P=0.054) at wk 1 was highest for 0.3% SS + 0.42% AC, with 0.23% NaCl intermediate, and 0.3% SS lowest. The 0.23% NaCl control had lowest oxygen consumption, heat production, and carbon dioxide exhaled, but third highest 3 wk weight. Hematocrit was negatively correlated (r^2=-0.53) with oxygen consumption or heat production. This confirmed a relationship previously found between lower oxygen consumption, lower heat production, higher hematocrit, and higher ascites score. Under simulated high altitude and moderate cool stress, young broilers had best 3 wk weight (541.7 g) and worst ascites score (0.74) with 0.28% Na and 0.39% Cl from 0.46% NaCl, which could be moderated to good weight (488.7 g) and ascites score (0.52) with 0.37% Na and 0.39% Cl from 0.46% NaCl + 0.3% SS.

Key Words: Ascites, Salt, Sodium sesquicarbonate

Nitrogen, Phosphorus, and Sulfur Interfaces Between Beef Cattle Production and the Environment

398 Federal environmental policy directions for animal agriculture. J.S. Jonker*, *AAAS Environmental Fellow - US EPA, Washington, DC USA.*

The animal agriculture industry has undergone dramatic changes in the past 20 years. The trend toward fewer but larger operations, coupled with greater emphasis on more intensive production methods and specialization, has concentrated more animal manure within some geographic areas. This increase in geographic concentration has led to an increasing concern over environmental impacts of animal agriculture. According to the 1998 *National Water Quality Inventory* which reported on assessments for 32 percent of the U.S. waters, 27,751 river and stream miles and 99,936 lake acres were impacted by animal feeding operations. A recent USDA analysis of 1997 county-level manure production relative to crop uptake in the United States estimated 73 counties had excess manure N and 160 counties had excess manure P. The number of counties with excess manure nutrients has significantly increased since 1982. Some manure could be exported to cropland in other nearby counties, but manure bulk will limit the distance manure can be transported economically. For many of these counties with excess manure nutrients, alternative uses for excess manure will need to be ex-

plored. The role of Federal regulation is to meet an endpoint goal, such as drinking water quality standards. Current and proposed Federal regulations do not dictate specific technologies or alternative uses for excess manure production. However, to meet endpoint goals for water quality, Federal regulations compel animal agriculture to find solutions to excess manure. Because regulatory approaches only impact 5 to 10% of all animal farms, voluntary and incentive based programs are also a vital part of the Federal environmental policy for animal agriculture.

Key Words: Environment, Federal Government, Water Quality

399 Phosphorus recommendations for beef cattle and factors related to their development and use. J.F. KARN*[1], [1] *USDA-ARS, Northern Great Plains Research Lab, Mandan, ND, USA.*

Current phosphorus recommendations for beef cattle will be discussed and research supporting these recommendations will be explored. Although recommendations have generally decreased in recent years, they must still contain some margin of safety, due to the many variables which affect beef cattle phosphorus requirements, especially under grazing conditions. There are many factors which make it very difficult to assess the true supplemental phosphorus needs of grazing cattle. Soil phosphorus levels are a reflection of soil parent materials and vary widely in the United States and around the world. Forage phosphorus levels reflect not only soil phosphorus levels and availability, but also forage species and stage of maturity. Animal affects include rumen microbial requirements; variation in absorption coefficients; interaction of phosphorus with nitrogen and other minerals; bioavailability differences among supplemental phosphorus sources; the availability of body stores of phosphorus and breed differences. Responses of grazing cattle to phosphorus supplementation have been inconsistent among and within geographical locations. Forage tissue phosphorus concentrations, as well as phosphorus concentrations in many animal tissues, have been considered as status indicators; but none have been consistently reliable. The impact of the above factors on phosphorus requirements, and phosphorus status indicators, as well as responses to phosphorus supplementation will be discussed. Additional knowledge is needed on many factors affecting phosphorus recommendations, and their practical application, to minimize production costs and to reduce phosphorus levels in effluent from pastures and feedlots which may affect the ecosystem of adjacent streams, ponds and lakes.

Key Words: Beef cattle, Phosphorus requirements, Supplementation

400 Effects of manipulating protein and phosphorus nutrition of feedlot cattle on nutrient management and the environment. T. J. Klopfenstein* and G. E. Erickson, *University of Nebraska, Lincoln, NE.*

Feedlot nutrition will play a role in meeting challenges such as nutrient management. Nitrogen and phosphorus are two nutrients that are currently studied in this context. One nutritional method is formulating diets to not exceed requirements for nitrogen and phosphorus. Requirements are different for calves versus yearlings. The requirements also change during the finishing period. Phosphorus requirements have not been extensively studied for feedlot cattle between 270 and 600 kg. Therefore, P requirement studies were conducted to determine the P requirement of calves (265 kg) and yearlings (385 kg). The requirement was not detected with P levels as low as .14 (yearlings) and .16% (calves) of diet DM based on performance and bone ash. Compared to NRC-predicted P requirements, P intakes ranged from 76 to 190% (calves) and 71 to 162% (yearlings). In separate nutrient balance experiments, decreasing dietary P to NRC-predicted requirements (.22 to .28%) did not influence gain but decreased P input by 33 to 45% and excretion by 40 to 50% when compared to industry average (.35% P). The metabolizable protein (MP) system was recently adopted and may allow more accurate diet formulation for protein, thereby decreasing N excretion. Compared to industry average (13.5% CP) and formulation with the CP system, using the NRC model and phase-feeding to not exceed MP requirements over the feeding period decreased N inputs by 10 to 20% for calves and yearlings without affecting ADG. Decreasing N inputs led to a concomitant decrease in N excretion (12-21%) and volatilization (15 to 33%) in open-dirt feedlot pens. Nitrogen losses are variable with time of year, with averages of 60 to 70% of excreted N lost during the summer months and 40% lost from November to May feeding periods. Protein requirements are continually being refined as more research data are collected. However, formulation to meet and not exceed protein requirements and removal of P supplements are important nutritional management options to help feedlots become more environmentally sustainable.

Key Words: Nitrogen, Phosphorus, Cattle feedlots

401 Livestock odor abatement with plant-derived oils and urease inhibitors. Vince Varel*, *USDA/ARS, U.S. Meat Animal Research Center, Clay Center, NE.*

Confined animal feeding operations are under environmental scrutiny for production of large quantities of waste in a small area. The waste can result in odor, global warming gases and the transfer of nutrients and pathogens to water and food sources. An incomplete anaerobic degradation of the carbohydrate, protein, and lipid components in waste is the primary cause of odor emissions. This incomplete degradation results in the formation of short-chain volatile fatty acids (VFA), amines and other nitrogenous compounds, and sulfur-containing compounds. Our objectives are to provide simple, cost effective, and environmentally sound solutions to control odor and pathogens in livestock waste, with nutrient management a top priority. A urease inhibitor, N-(n-butyl) thiophosphoric triamide, was used to reduce urea hydrolysis in beef cattle feedlot pens, conserve nitrogen, and inhibit ammonia emissions which contribute to odor. Laboratory studies with antimicrobial plant-derived oils, thymol and carvacrol, at 2 g kg^{-1} of feedlot waste completely inhibited the production of VFA in flasks over 42 days. Fecal coliforms were reduced from 4.6 x 10^6 to 2.0 x 10^3 cells ml^{-1} 2 days after treatment, and were nondetectable within 4 days. Total anaerobic bacteria were reduced from 8.4 x 10^{10} to 1.5 x 10^7 cells per ml after 2 days and continued to be suppressed to that level after 28 days. These plant oils are not degraded under anaerobic conditions. However, our feedlot studies and the literature indicate these oils are degraded under aerobic conditions. This suggests that these generally recognized as safe (GRAS) chemicals, which are routinely used as preservatives in food and personal care products, should not accumulate in soils to which this waste is applied. It is concluded that chemical additives can be added to animal waste to prevent degradation, which in turn controls odor emissions, reduces pathogens, and conserves nutrients until the waste can be recycled as fertilizer. The economics and environmental effects of using thymol and carvacrol in livestock production facilities need to be determined.

Key Words: Livestock Waste, Odor, Essential Oils

Companion Animal Biology as a Focal Point in the Animal Sciences

402 Issues surrounding the teaching of companion animal biology in an animal science department. Neal R. Merchen* and Linda P. Case, *University of Illinois, Urbana, IL.*

Animal Sciences departments are increasingly faced with decisions about inclusion of courses and training programs related to companion animals in their curricula. Companion animals are economically important through sales of pet food and other accessories and payment for veterinary services. The pet food manufacturing industry uses large quantities of agricultural commodities. Demographics of students have changed such that the majority of students in many Animal Sciences departments are now women, come from urban backgrounds, and target advanced study (veterinary medicine, other professional curricula, graduate study) as goals following completion of their undergraduate programs. These characteristics often reflect students whose primary animal-related experiences and interests are with companion animals. Thus, Animal Sciences departments need to consider curricula additions that include more training in companion animal biology. A curriculum in companion animal biology has been developed at the University of Illinois. Courses are taught in Companion Animal Biology (general survey of all disciplines related to companion animals) and Human-Companion Animal Interactions. A course in Companion Animal Nutrition has been developed and is offered to junior-senior and graduate students. In ad-