ARPAS Symposium: Applied Nutrition of Ruminants—Current Status and Future Directions

302 Nutrient requirements: Derivation, validation, and application. M. L. Galyean*, *Texas Tech University, Lubbock.*

Systems for describing nutrient requirements of animals are intrinsically composed of 2 parts: (1) estimates of animal requirements for nutrients; and (2) estimates of the ability of feedstuffs to meet requirements. Ultimately, these systems contribute to animal health and well-being, but for application, they also should provide a means to reliably predict animal performance and adjust feeding and management practices to achieve economic goals. Changes in feed intake and nutrient requirements associated with sex, breed, physiological state, and the environment add to the complexity of modeling animal requirements. Moreover, the wide variety of feedstuffs used in practical diets and inherent variability in nutrient content within a given ingredient complicate description of feedstuffs. In the US, nutrient requirements for livestock species have been developed by volunteer committees working under the auspices of the Board on Agriculture and Natural Resources of the National Research Council (NRC). Animal nutrient requirements have typically been determined by empirical approaches based on reviews of the literature and analysis of derived and experimental data sets. In recent years, validation of nutrient requirement equations has become an increasingly important part of the NRC process, although the lack of independent data to validate equations continues to be a problem. In the last 2 decades, NRC committees also have emphasized the development of computer models to facilitate practical application of nutrient requirement systems. Although user-friendliness and functionality of these models has improved over time, more effort is needed to ensure that models allow for efficient, practical application of the systems. In addition to issues with validation and model development, describing the concentration and availability of nutrients in feedstuffs is a significant challenge for NRC committees. The recently formed National Animal Nutrition Program, funded through USDA-NIFA, should play an important role in interacting with NRC committees, particularly in providing support for feed composition databases and development and evaluation of computer models.

Key Words: livestock, nutrient requirements

303 Applied nutrition of ruminants: Fermentation and digestive physiology. C. R. Krehbiel*, *Oklahoma State University, Stillwater.*

Since the first observation of the 4 chambers and subsequent identification of its microbial population, the rumen has been investigated for its role in nutrient digestion and to manipulate its microbial ecosystem to increase animal performance and efficiency. Ruminants have the ability to digest plant polysaccharides through substrate-specific enzyme activities of the highly specific population of ruminal bacteria, protozoa, and fungi. A synergistic relationship provides these microorganisms with nutrients, ambient temperature, and a buffered environment to enhance microbial growth, while the microbes provide the host animal with B vitamins, VFA, and microbial cell protein. Microbial populations are not stable and fluctuate with changes in the ruminal environment and diet, resulting in changes in VFA composition and concentration. Recent research using T-RFLP analysis, 16S rDNA libraries, and metagenomic approaches has increased our understanding of the importance of microbial communities within the rumen and the microbial diversity under different dietary environments. Increased understanding of these changes in microbial communities could result in increased microbial growth rates and enzyme secretions in the rumen, resulting in increased digestibility, nutrients delivered to the small intestine, and animal production and efficiency. In addition, increased understanding of molecular-level adaptation of ruminal epithelia and gastrointestinal mucosa may provide the physiological basis for their role in regulation of ruminal pH and nutrient transport. Recent advances and continued study in the area of ruminal fermentation and digestive physiology have the potential to positively affect animal production, health and the environment.

Key Words: digestive physiology, ruminal fermentation, ruminant nutrition

304 Carbohydrates and fat: Considerations as energy and more. M. B. Hall*[1] and M. L. Eastridge[2], *[1]US Dairy Forage Research Center, USDA-ARS, Madison, WI, [2]Department of Animal Science, The Ohio State University, Columbus.*

Historically, carbohydrates and fats were valued on their caloric contributions to diets. Feeding recommendations for these feed fractions now address inclusion levels as well as consideration of the positive and negative effects of specific types of these nutrients. Feed carbohydrate characterization has expanded beyond fiber and nonfiber carbohydrates (NFC). Fiber now encompasses ADF, NDF, physically effective fiber, and fiber digestibility to describe the effect on diet composition, rumination, rumen fill, potential fermentability, and nutrient contribution. The NFC is now parsed into sugars and fructans (both in water-soluble carbohydrates), starch, pectins, and others, all of which may differ in their effects on rumen pH or support of microbial growth. Dietary fat has the advantage of providing energy without increasing the risk of ruminal acidosis. However, there are specific considerations for amounts and types fed in high vs. low forage diets. Fats can affect ruminal fermentation, having the potential to depress fiber digestion or affect ruminal methane production. Considerable research in recent years has focused on providing specific dietary fatty acids (FA) to alter the metabolic function of specific tissues or to alter the FA content of milk for nutraceutical purposes. Rising grain prices and diversion of fats for biofuel are driving livestock industries to seek alternative nutrient sources. Most of the nutritional research on which current recommendations are based involved the use of traditional diets which tended to be rich in grains. Fat and carbohydrate feeding recommendations may need to change with diets high in low starch byproducts. We need to learn how diets with substantially more byproduct feedstuffs ferment, and pass from the rumen, and how they affect nutrient supply and feed efficiency. We can then better predict digestion and the effects on metabolism and thus target supplementation to have the greatest positive effect on food animal production.

Key Words: carbohydrate, fat, ruminant

305 Applied protein nutrition of ruminants—Current status and future directions. F. N. Owens*[1], S. Qi[1], and D. A. Sapienza[2], *[1]DuPont Pioneer, Johnston, IA, [2]Sapienza Analytica, Slater, IA.*

Protein nutrition of ruminants is at a low level of sophistication. Cost and availability of various N sources dictate which will be fed whereas the quantitative supply is selected largely without empirical data. Lack of sophistication is due to imprecision in measuring responses, inadequate methods to quantify degradation and biosynthesis of protein within the rumen, insufficient knowledge about post-ruminal availability and amino acid needs for various metabolic functions, inconvenience of preparing or delivering diets customized for animal groups with different needs, and unrestrained expectations. Much of the dietary N need for ruminants is met by proteins inherent in energy sources fed (grains, forages, and byproducts). No response to improved protein status should be expected if a diet already yields optimum performance! Experimental designs testing applicable concepts often lack appropriate controls. Commercial successes in protein nutrition have been limited to 3 areas – physical or chemical modification of feeds to alter degradation of dietary protein, NPN products with attenuated ammonia release, and ruminally protected amino acids. Future improvements in protein nutrition likely will come from targeted, small-package supplements or boluses that alter the native microbial population within the rumen or rumen function, not from feedstuffs customized for ruminants or inoculation with novel microbes. New DNA sequencing methods are improving our comprehension of changes in the rumen microbiome. Ruminally protected amino acids could be supplemented more precisely if needs for absorbed amino acids were defined quantitatively, but metabolic requirements should parallel those of non-ruminants for maintenance and production. More practical and economical advancements would be expected from enlightened research about and manipulation of numerous factors to increase the post-ruminal protein supply through a decrease in ruminal proteolysis or an increase in microbial protein synthesis within or flow from the rumen.

Key Words: protein, microbiome, rumen-undegraded protein

306 Mineral and vitamin nutrition in ruminants. J. W. Spears*, *North Carolina State University, Raleigh.*

Requirements and factors that affect dietary requirements for several trace minerals and vitamins in ruminants are still poorly defined. Most B-vitamins and vitamin K are believed to be synthesized by bacteria in the rumen in adequate amounts to meet the animal's requirement. However, several studies indicate that supplementing high producing dairy cows with approximately 20 mg biotin/d can reduce hoof lesions and lameness, and in some instances increase milk yield. The vitamin E requirement for optimal immunity and health in receiving cattle and transition dairy cows continues to be an area of interest, with responses to supplementation varying greatly. Macromineral research in recent years has focused primarily on P and S. Studies clearly indicate that P requirements of cattle are lower than those recommended 20 years ago. Because of increased use of ethanol by-product feeds that are high in S, considerable research has been conducted to determine the effects of high dietary S (in feedstuffs and water) on performance and incidence of polioencephalomalacia. Requirements for certain microminerals are affected by antagonists. Sulfur and Mo are important Cu antagonists that can greatly affect dietary Cu bioavailability, and therefore, requirements. High dietary Fe, when present in a bioavailable form, is a potent Cu and Mn antagonist. Recent research suggests that NRC recommendations for Co and Mn may underestimate requirements. In the past 3 years Cr (in the form of Cr propionate) has been permitted to be supplemented at a maximum concentration of 0.50 mg Cr/kg DM to cattle diets. Chromium enhances insulin sensitivity and responses to supplemental Cr appear to be greatest under conditions of stress (i.e., transition dairy cows, receiving cattle), where insulin resistance commonly occurs. Research continues to increase the understanding of mineral and vitamin requirements of cattle in different production systems.

Key Words: mineral, vitamin, ruminant