ARPAS-Ruminant Nutrition Joint Symposium: Nutrition Models–Where Are We Going in the Next Decade?

425 The role of models in animal nutrition: Research and field applications. J. A. Metcalf* and N. S. Ferguson, *Nutreco Canada Inc*, *Guelph, Ontario, Canada*.

Mechanistic mathematical models are essential to the interpretation of data from scientific experimentation, since they can be used to explain and predict outcomes. The more inclusive the theory behind the model, the more accurately the outcome can be explained or predicted, while at the same time being at risk of error due to inadequacy in the theoretical framework or scientific understanding. Nevertheless a sound biological model offers a powerful tool which requires that the parameters used to design and/or drive the model be fully understood by the user. Modeling and experimental design can be used together in research models, with the model used to identify areas where further investigation is required, while the experimental results can be used either to validate or further develop the model. There are many models used in practical animal nutrition, usually relating to diet formulation, predicting growth and the interaction of nutritional parameters with genetics and environment. Successful field models are those which have a sound mechanistic basis, allowing the incorporation of new technologies, such as rumen active feed additives or digestibility analyses. These technologies must be rigorously tested so that the impact on the model is predictable under field conditions, and training for the users requires that they understand the limitations of the model. Applied models which incorporate financial impacts, such as carcass grading or milk composition, as well as the cost of the nutrition, are essential for better decision making on farm. One extension of this is the ability to generate multiple solutions by allowing nutritional inputs to vary, in order to demonstrate to the producer the cost of changing objectives on milk production or growth. A frequent failing of applied models is at the user interface. Focusing on the ease of use by providing adequate default settings and a logical approach to diet formulation or evaluation can increase the usefulness of a model, and is an area which is undervalued.

Key Words: mechanistic modeling, nutritional models, diet formulation

426 Nitrogen recycling and rumen degradable protein requirements: Quantitative updates to describe microbial requirements, sources, and applications in ration formulation. M. E. Van Amburgh*, E. B. Recktenwald, D. A. Ross, R. J. Higgs, T. R. Overton, and L. E. Chase, *Cornell University*, *Ithaca, NY*.

Estimating the requirements for ruminal nitrogen (N) is a function of microbial demands driven by the availability of rumen fermentable carbohydrates for microbial growth. To improve overall efficiency of use and to reduce the environmental impact of N from cattle, we need to refine our estimates of ruminal N demand and supply to minimize urinary N excretion. The ruminant is an obligate recycler of N designed to conserve N in times of limitations in an effort to maintain an optimal microbial population. The objective of this abstract is to present a quantitative description of the demand and supply of ruminal N for a field application model. Recent work has indicated that recycled N to meet ruminal demands are greater and more constant than previously considered, are a function of intake N and are supplied as ammonia N and peptide N. Further, the current characterization of soluble protein into non-protein N and true protein has under-estimated the peptide content of the soluble protein fraction of feeds, particularly of forages, which has confounded not only estimations of rumen available N, but also metabolizable protein supply. Urea N synthesis is directly related to N intake and review of our work and the literature shows the conversion of intake N into urea N generally ranges from 50 to 70%. The proportion of N intake that reenters the gastrointestinal tract (GIT) as urea-N in the dairy cow is on average 30–45%. Microbial capture of the recycled N is of greatest interest and what impacts efficiency of use. Other sources of rumen available N are endogenous N and microbial turnover. Measurements of endogenous N flows through the rumen range from 5 to 15% of the total N supply, contribute to the rumen available N supply as peptides, are taken up by the microbes and constitute up to 15% of the microbial protein supply, which is comparable to the amount of bacterial N coming from recycled urea N. In addition, the use of N by protozoa and the interaction of protozoa with the bacterial pool will also be discussed.

Key Words: recycled N, RDP, modeling

427 Tackling the variable efficiencies in post-absorptive amino acid utilization. M. D. Hanigan*[1] and E. C. Titgemeyer[2], [1]*Virginia Polytechnic Institute and State University*, *Blacksburg,* [2]*Kansas State University*, *Manhattan*.

Productive performance of all animals including ruminants is nutrient dependent. While excess energy can be stored in times of excess, the ability to store amino acids (AA) is extremely limited. Thus, performance declines when AA supplies are limiting and excess AA are degraded when supply exceeds demand. Matching AA supply and tissue needs thus requires an accurate representation of the efficiency with which absorbed AA are utilized. The current NRC ruminant models assume that conversion of absorbed AA to product is high and constant when supply is at or below requirements. However, there is significant evidence that efficiency of conversion is moderate and variable. The assumption of constant efficiency is predicated on the concept of a single limiting nutrient. That paradigm dictates that productive output will increase in a linear manner in response to a nutrient until another nutrient becomes limiting or genetic potential is reached at which point productive responses will abruptly cease. In this scenario, the metabolic machinery remains constant and substrate supply dictates the rate of production. However, emerging work on the regulation of protein synthesis within the cell clearly supports the role of both AA and energy status as regulators of protein synthesis and AA extraction from blood resulting in continuously variable metabolic efficiency and demand. Further these data are not supportive of the single limiting nutrient approach. We have begun to build models representing both the substrate and regulatory effects of AA, energy yielding substrates, and hormones at the tissue level. These lower level models must be aggregated across tissues and consolidated into a postabsorptive system that is capable of predicting efficiencies for at least the essential AA over a range of conditions. Such a system should allow diet formulation to achieve animal N efficiencies of 40% or greater which will dramatically reduce N loss to the environment and may reduce feed costs.

Key Words: amino acid, requirement model, ruminant

428 VFA production and absorption: Modeling the impacts on energy availability.

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Current feed evaluation systems aim to match supply and requirement for various nutrients. These systems are largely empirically based and fail to address the underlying mechanisms causing variation in feed digestion and nutrient absorption. Modeling exercises were undertaken to evaluate these mechanisms with a distinct representation of rumen, small intestine and large intestine functioning. Volatile fatty acids (VFA) are the main source of metabolizable energy and propionic acid the main glucose precursor. Their accurate estimation is a prerequisite to understanding variation in ruminant performance. Published VFA prediction methods differ in approach, type of information used, and level of detail represented. Substrate fermented (or bypassing rumen fermentation) is estimated from rates of outflow and degradation. The type of rumen VFA produced is mostly associated with the type of substrate fermented or some general dietary characteristics. But, details of rumen fermentation processes or intraluminal conditions are rarely taken into account. Also, the concepts used and presumptions made in rumen modeling efforts may restrict the possibilities to apply these representations of VFA production. The large intestine delivers a minor fraction of total VFA production (on average some 10%) but variation in hindgut fermentation is large and should be taken into account to obtain accurate estimates of the total tract VFA production. The absorption of VFA depends on the amount of VFA produced as well as on intraluminal conditions and rumen wall characteristics. Intraluminal state and VFA absorption rate are mutually dependent, rumen epithelia strongly adapt to intraluminal conditions, and intraluminal state affects rumen fermentation as the source of VFA. This means that for an understanding of the contribution of enteric fermentation to feed digestion and energy absorbed as VFA, these aspects need to be considered simultaneously.

Key Words: digestibility, VFA, modeling

429 Predicting dry matter intake responses: Modeling the influence of cattle management.

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Prediction of dry matter intake (DMI) may be improved by combining measures of the animal physical and social environment with traditional inputs such as body weight, milk production, stage of lactation, or dietary energy density. Rudimentary attempts have been made to adjust DMI predictions directly and indirectly based on environmental factors such as temperature, humidity, wind speed, degree of muddiness, hair coat, and distance walked. In the next decade, nutritional models will increasingly incorporate inputs such as stocking density, grouping strategy, and parity effects that characterize key components of the social environment and influence the animal response to diet. For instance, research shows that short-term daily DMI is unaffected by pen stocking density of stalls and feed manger, but feeding rate within a meal may be increased by up to 25%. Consequently, dynamic models will be required to accurately predict the impact of varying stocking densities on feeding, rumen conditions, and performance. Commingling primi- and multiparous cows often reduces the daily DMI of the younger, subordinate animals and also affects feeding rate and meal patterns. An input for parity will be useful in static and dynamic nutritional models. Time budget analysis of eating and resting times will ensure that adequate time is available for predicted daily DMI. Inputs related to the feeding environment such as feeding frequency and feed availability also affect DMI. The feeding environment specifically determines achievable DMI, in contrast to predicted DMI, and future models must accurately capture the key inputs and how these environmental factors influence feeding behavior and DMI. Currently, research that evaluates the effects of the social and physical environment on behavioral responses as well as DMI is limited, but it will be needed to improve nutritional models over the next decade. The Cornell Net Carbohydrate Protein System model (version 6.1) will be used to illustrate what may be implemented now and in the future to better predict DMI with a specific focus on dairy cattle.

Key Words: dry matter intake, nutrition models, social and physical environment