The Ruminant Nutrition System

An Applied Model for Predicting Nutrient Requirements and Feed Utilization in Ruminants

Second Edition

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Preface to the Second Edition

The first edition of *The Ruminant Nutrition System: An Applied Model for Predicting Nutrient Requirements and Feed Utilization in Ruminants* was published in October 2016. Since then we have received much positive feedback, which has encouraged us to revise and expand it. In this second edition, we have updated concepts and added new information, clarified and enhanced the discussions of important topics, included new and improved and standardized existing graphics and illustrations, rearranged some of the text, and included indexes for subjects and authors.

In Chapter 1, we added additional supporting material for mechanistic modeling and moved the discussion of animal welfare to the *Contemporary Perspective* section. In Chapter 2, we added visual support for the software SEEPAD and updated its information. In Chapter 3, we updated the data presented in Table 3.1 and Figures 3.1, 3.2, and 3.3 and reflected these changes in the text. In Chapter 4, we included the origins of the concept of first limiting nutrient, a concept fundamental to many parts of the book. In Chapter 5, we added information on other chemical analysis assays used in the UK, and we expanded the discussion of and added references for important concepts such as fecal nitrogenous components, the proximate analysis, and the impact of silica on the digestibility of rice straw. In Chapter 6, we expanded the explanation for using the level of solution 0, and we included recent information about the efficiency of converting digestible energy to metabolizable energy. In Chapter 7, we added to the discussion about microbial nitrogen composition and its interconversion with microbial crude protein. In Chapter 8, we added discussions about the energetics of synthesis and methodology pitfalls of condensed tannins, expanded the materials on biohydrogenation of lipids in the rumen, and included illustrations of the effect of ruminal pH on the fractional absorption rates of volatile fatty acids and lactate. In Chapter 10, we listed additional predictive equations of dry matter intake for lactating dairy cows. In Chapter 11, we added a discussion of the importance of dietary fiber for ruminants, its potential status as a requirement, and its effect on limiting dry matter intake for cattle and sheep. In Chapter 13, we included information about lactation and milk composition for different breeds of sheep and goats in Table 13.7. In Chapter 14, we updated the discussion about fetal programming. In Chapter 15, we expanded the retained protein evaluation database by including data from the Midwest of the United States. In Chapter 18, we included information about existing online feed libraries to expedite the acquisition of feedstuff composition. The second edition now contains 2,372 scientific references spread across eighteen chapters and nine appendices.

We believe this second edition of *The Ruminant Nutrition System* is a lot more inclusive and complete, but we cannot accommodate and stop here. We must be alert, always seeking for new ideas and how to implement them. Some branches of sciences experience rapid progress because of their economic relevance, as well as the pace of their development and application of novel technologies. One example of such progress is the ability to manipulate microorganisms genomically to produce biofuel more efficiently and in a more sustainable way. For example, Davidi et al. (2016) successfully added a laccase, or lignin-degrading enzymes, from the aerobic bacterium *Thermobifida fusca* into a designer cellulosome, a multi-enzyme complex structure commonly found in anaerobic bacteria. The resultant chimera had the ability to degrade cellulose, hemicellulose, and lignin simultaneously. This use of laccase may be an early example of the rapid application of this long-known enzyme (Claus, 2004; Thurston, 1994) in biofuel production and other industries, such as pulp and paper and crop biotechnology. Applications of such technology in ruminant nutrition might yield enormous benefits not yet realized, even though its adoption may not happen in the near future. This technology may eventually change the way we understand indigestible dietary compounds. Rapid scientific developments such as this pose an interesting challenge for nutrition modeling. They require nutritionists to be constantly aware of discoveries and determine how to adopt them in the livestock industry. It is imperative that nutrition modeling follow the same pace of technological evolution and be responsive to new breakthroughs.

When we started writing the first edition of *The Ruminant Nutrition System* in 2006, the idea of sustainable agriculture was gaining momentum. Unfortunately, however, the concept of sustainability has often been so muddled with the ideology of "organic agriculture" that many have been reluctant to embrace it. Sustainability has been evolving since the 1950s, when multiple lines of thoughts independently emerged to address different concerns: ecological and carrying capacity, resources and environment needed to sustain population growth, biosphere and human activity, critique of the dehumanizing and disorganizing effects of technology and advancement, the "no growth-slow growth" accumulation of wealth by most persons in the world, and the ecodevelopment concept to harmonize social and economic objectives within an ecological perspective (Kidd, 1992). Though these different concepts share sustainability as an intrinsic goal, a common definition seems implausible making it harder to establish objectives across multidisciplinary fields within agriculture. Regardless, sustainability is still a very important issue, and livestock production can benefit from implementing it in many different ways. At the very least, sustainability will reward the most efficient and consumer-oriented farmer or rancher, and at most it will provide the same amount of animal products produced today but by using renewable resources and without harming the environment. Additionally, new research has increased public awareness of the true benefits of ruminants as a high-quality food source for humans. The research indicated that, on a global, human-edible basis, ruminants are 12.5% more efficient in feed conversion than monogastrics, confirming previous reports in Section 3.1. For each 1 kg of boneless meat produced, ruminants need 2.8 kg of human-edible food whereas monogastrics need 3.5 kg (Mottet et al., 2017). The authors also highlighted that ration formulation and balancing is poorly done in many parts of the world, further confirming our belief that ruminant nutrition models have an important role to play in improving feed efficiency. In this second edition of *The Ruminant Nutrition System*, we continued our focus on describing how mathematical nutrition models can assist with sustainability efforts, especially within the sustainable livestock intensification approach.

Like the first edition, many colleagues were instrumental in providing positive comments and knowledgeable suggestions to improve not only *The Ruminant Nutrition System* book, but the software as well. We are especially indebted to Antonello Cannas (University of Sassari) and Mozart Fonseca (University of Nevada, Reno) for their reinvigorating optimism and endless support to *The Ruminant Nutrition System* project. Our gratitude is unbounded to Peter Van Soest (Cornell University) for his thorough review and suggestions for Part II, *Modeling the Dietary Supply of Energy and Other Nutrients*.

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Table of Contents