

Satter L D & Roffler R E. Nitrogen requirement and utilization in dairy cattle.
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A review of protein requirements and protein utilization by dairy cows is presented, and a model for predicting the amount of protein available for absorption in the ruminant intestine is introduced. This model is superior to methods based on dietary crude protein for estimating dietary protein needs of lactating dairy cows. [The *SCF*® indicates that this paper has been cited in more than 200 publications.]

Utilization of Protein by the Dairy Cow

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The conversion of dietary protein to microbial protein in the ruminant's stomach, and subsequent utilization of the microbes to meet the animal's protein requirement, has been recognized for 50 or more years. It wasn't until the late 1960s, however, that some understanding of the quantitative aspects of microbial protein synthesis in the rumen was expressed. At this time, it was also becoming apparent that feed proteins differed greatly in their susceptibility to microbial hydrolysis in the rumen. This had obvious implications regarding protein nutrition of the ruminant animal. Wise Burroughs, at Iowa State University, was the first to suggest a model that recognized the dynamics of protein transformation in the rumen. This model was intended for use in formulating diets that would meet the protein requirements of beef cattle. The first publication of his was in 1972 as a University Extension leaflet, and it appeared later in journal form.¹

The senior author, L.D. Satter, became involved in this area of research in the late 1960s, largely due to the stimulating work of J.P. Hogan and R.H. Weston.² Experiments dealing with microbial protein synthesis as a function of ammonia concentration in the rumen were completed in 1972, while Satter was on sabbatical leave, and this research resulted in a paper that

was later to become a *Citation Classic*.³ Later in the year, Bob E. Roffler, recently having spent four years in Brazil on a University of Wisconsin teaching-research assignment, joined Satter for a most enjoyable and productive collaboration, lasting five years. The two of us had many discussions over bag lunches, usually on the topic of nitrogen utilization by ruminants. We were invited to present a symposium paper at the 1974 American Dairy Science Association meeting—the subject of this *Classic*.

Our paper was basically a review, but it also contained a model we proposed for predicting the amount of protein that would be available for absorption from the ruminant intestine. Our model differed substantially from the earlier one of Burroughs, but the two models had essentially the same outcome. Burroughs's model was very detailed, and in one sense was ahead of its time. It relied on much information about feedstuffs that was not available, and numbers had to be "dubbed" in. Our model was simpler, and we felt it was closer to experimental evidence available at the time. We entertained thoughts that our model might be useful in formulating diets until more detailed information on microbial protein degradation and synthesis would be available to formulate diets based on the quantity of amino acids made available for intestinal absorption. It never was used for this purpose, however.

Our paper, along with a number of others around the mid-1970s, helped focus discussion on the need for altering the prevailing views of protein nutrition of ruminants. The ensuing discussion, to our surprise, was often controversial. Several systems or models for formulating protein sufficient diets for ruminants are now widely used in Western Europe and North America.⁴⁻⁶ They are rooted in the introductory models of the early and mid-1970s.

We are honored by the interest in our paper. It came from a period of time that was particularly fruitful and satisfying for us as investigators. We both had numerous opportunities to discuss our work at nutrition conferences. This paper, along with the *Citation Classic* mentioned earlier, were the major reasons for Satter being recognized with several feed industry awards in the ensuing years.

1. Burroughs W, Trenkle A H & Vetter R L. A system of protein evaluation for cattle and sheep involving metabolizable protein (amino acids) and urea fermentation potential of feedstuffs. *Vet. Med. Small Anim. Clin.* 69:713-22, 1974.
2. Hogan J P & Weston R H. The digestion of two diets of differing protein content but with similar capacities to sustain wool growth. *Aust. J. Agr. Res.* 18:973-81, 1967.
3. Satter L D & Slyter L L. Effect of ammonia concentration on rumen microbial protein production in vitro. *Brit. J. Nutr.* 32:199-208, 1974. (Cited 275 times.) [See also: Satter L D & Slyter L L. *Citation Classic. Current Contents/Agriculture, Biology & Environmental Sciences* 20(19):20, 8 May 1989.]
4. Agricultural Research Council. *The nutrient requirements of ruminant livestock*. Slough, England: Commonwealth Agricultural Bureaux, 1984. 40 p. Supp. 1.
5. Subcommittee on Dairy Cattle Nutrition, National Research Council. *Nutrient requirements of dairy cattle*. Washington, DC: National Academy Press, 1988. 157 p.
6. Jarrige R, ed. *Ruminant nutrition. Recommended allowances and feed tables*. Paris, France: John Libbey Eurotext, 1989. 389 p. Received February 14, 1992.