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Cornell Net Carbohydrate and Protein System: A model for precision feeding of dairy cattle☆

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Abstract

The Cornell Net Carbohydrate and Protein System (CNCPS) predicts cattle requirements and nutrient supply for site-specific situations. This paper describes the CNCPS version 6 (CNCPSv6), which represents a re-engineering and updating of CNCPS version 5 with the following objectives: (1) improve the organization of the model and user interface to improve speed and accuracy in formulating diets for a herd of dairy cattle, (2) expand the carbohydrate pools to include sugars, soluble fibers, and organic and volatile fatty acids, (3) integrate a fat model to account for ruminal lypolization and biohydrogenation, and absorption of fatty acids in the small intestine, and (4) update the computational sub-models with new information. The CNCPSv6 model was re-designed using object-oriented programming in which physiological functions (*e.g.* growth, lactation, pregnancy) and anatomical compartments (*e.g.* rumen, intestines) were programmed as objects. The interface uses farm, location, and group flow, which decreases the number of inputs required per cattle group and allows for more rapid evaluation of diets, feed requirements, and nutrient excretion by location, group, and herd. The revised implementation of the body reserves sub-model allows accounting for fluxes in energy reserves when formulating diets. Updated equations and coefficients include the prediction of rumen ammonia balance and feed passage rates, indigestible DM, MP lactation efficiency, and

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DMI. The CNCPSv6 was evaluated with data from individually fed lactating dairy cows from three independent studies. As implemented, CNCPSv6 accounted for a similar proportion of the variation (86%) in first limiting (ME or MP) milk production as CNCPSv5 but with a lower bias (1% *versus* 4%, respectively). We concluded the re-designing and updating of the CNCPS improved its ability to formulate and evaluate a feeding program for a herd of dairy cattle with greater accuracy and efficiency.

Keywords: Modeling; Simulation; Cattle; Nutrient; Requirement; Supply; Rumen

1. Introduction

The Cornell Net Carbohydrate and Protein System version 5 (CNCPSv5) is a model designed to evaluate diets and animal performance for all classes of cattle in unique production situations, using science-based principles of rumen function, microbial growth, feed digestion and passage, and physiological state (Fox et al., 2004). By accounting for farm-specific animal, feed, and environmental characteristics, more accurate prediction of dietary nutrient requirements for maintenance, growth and milk production of cattle and nutrient excretion in diverse production situations is possible. The CNCPSv5 model was used as the biological structure for developing a computer program for consulting dairy nutritionists to use in formulating rations for individual groups in a herd through a collaborative effort by scientists at Cornell University, University of Pennsylvania, and Miner Institute. The result of this collaboration was the development of the CPM Dairy model (Boston et al., 2000). The CNCPS version 5 and CPM Dairy version 3 software are being routinely used by both nutritional consultants and feed companies. The CNCPS has been used as a farm management tool to optimize use of farm-specific feeds, decrease the need for purchased supplements, optimize herd size, predict the manure nutrients that will have to be managed, and improve the annual return over feed cost (Tylutki et al., 2004; Fox et al., 2004). However, the software interface was not designed for efficient routine use in developing whole herd feeding plans. The United States Department of Agriculture National Resource Conservation Service (USDA-NRCS) identified the need to improve herd feed management to reduce manure nutrients, and to address this issue has developed a Feed Management Standard for use in nutrient management planning on farms. The purposes of the USDA-NRCS 592 standard are (1) to supply the quantity of nutrients required by livestock in the diet while reducing the quantity of nutrients excreted, and (2) to improve net farm income by feeding nutrients more efficiently (USDA-NRCS, 2003).

The objective of this paper is to describe the re-designed CNCPSv5 and to evaluate its prediction in meeting the USA NRCS Feed Management Standard objective of more accurately supplying the quantity of energy and protein required in the diets of dairy cattle on USA dairy farms for milk production.

2. Model development

This model must predict the following for each animal group (and the whole herd) when accounting for nutrient management: (1) accurately predict the nutrient requirements and