

Application of the Ruminant Farm Systems model (RuFaS) to assess the environmental impact of reproductive strategies in dairy farms

K. Reed¹, PhD; D. Nydam¹, PhD, DVM; M. Li², BS; V. Cabrera², PhD

¹Cornell University, Ithaca, New York, 14850;

²University of Wisconsin, Madison, Wisconsin 53705

Introduction

Dairy producers are challenged to meet goals to produce milk in an economically viable and socially acceptable way that minimizes environmental footprints and maintains cow health. In support of their work, producers, managers and consultants use a variety of decision support tools. However, most of these tools focus on specific parts of the dairy operation and are not able to predict how changing one part of the system will influence others. Whole farm models integrate all parts of a farm operation and can be useful management tools illustrating impacts of sets of management choices. Models are the most practical method to estimate environmental outcomes like greenhouse gas emissions, nutrient leaching and soil erosion, which are commonly required to gain access to certain markets, meet environmental regulations, or participate in ecosystem service markets. Unfortunately, most existing whole farm models are not built to be decision support tools and are limited in the management practices they can represent. Because of this, we are building a new whole farm modeling platform called the Ruminant Farm Systems model. Here, we focus on the animal component of the whole farm model with the objective of illustrating the impacts of different reproductive strategy choices.

Materials and methods

RuFaS tracks and maintains a mass balance of the flows of nitrogen, carbon, and phosphorus through four biophysical modules; soil and crop, feed storage, animal herd, and manure. The model functions at a daily time-step and uses modern coding methods to build and expand upon existing models like IFSM, Daycent and SWAT. The user determines farm management and biological characteristics through model inputs. The animal module simulates the key life events, feeding and production of individual animals as they move through different life stages and are grouped into pens of animals with similar characteristics. An automated ration algorithm formulates the least-cost diet and lactating cows can be grouped into any number of feeding groups. Reproduction protocols can be assigned to heifers and cows separately. Here, we present a 2x2 scenario comparison of 2 cow reproduction protocols (5dCoSynch with a mean conception risk of 0.4 or Ovsynch56 with a mean conception risk of 0.55) and 2 voluntary waiting period lengths (65d or 85d) in a 1,000-cow Holstein herd. In addition to producing outputs of herd demographics and reproduction performance, we provide outputs to demonstrate model ability to simulate the influence of reproduction management on the number of calves born and methane and manure production intensity per kg of milk.

Results

As expected, the average calving interval is longer in scenarios with longer voluntary waiting period (VWP) and the 5dCoSynch protocols. Fewer calves were born per year in scenarios with the longer VWP within the same protocol and close to 60 more calves were born in the scenarios with OvSynch56 vs. 5dCoSynch protocols. Feed intake and manure, methane and milk production suggest a VWP of 65 days compared to 85 days decreases methane intensity by approximately 0.2 g CH₄/kg and production of manure degradable volatile solids by around 3-4 g/kg milk. Similarly, the OvSynch56 protocol, when compared to the 5dCoSynch protocol, reduced methane intensity by approximately 0.4 g CH₄/kg and manure degradable volatile solids by around 6-7 g/kg milk.

Significance

As the industry continues to recognize the importance of evaluating the environmental impacts of dairy production, tools to compare outcomes of different management practices are needed. These results illustrate the unique capability of RuFaS to connect reproduction performance to herd environmental outcomes and suggest that shorter voluntary waiting periods and reproduction protocols with higher conception rates reduce the environmental footprint per kg of milk.

