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Economic impact of nutritional grouping in dairy herds

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ABSTRACT

This article evaluates the estimated economic impact of nutritional grouping in commercial dairy herds using a stochastic Monte Carlo simulation model. The model was initialized by separate data sets obtained from 5 commercial dairy herds. These herds were selected to explore the effect of herd size, structure, and characteristics on the economics and efficiency of nutrient usage according to nutritional grouping strategies. Simulated status of each cow was updated daily together with the nutrient requirements of net energy for lactation (NE_L) and metabolizable protein (MP). The amount of energy consumed directly affected body weight (BW) and body condition score (BCS) changes. Moreover, to control the range of observed BCS in the model, constraints on lower (2.0) and upper (4.5) bounds of BCS were set. Each month, the clustering method was used to homogeneously regroup the cows according to their nutrient concentration requirements. The average NE_L concentration of the group and a level of MP (average MP, average MP+0.5SD, or average MP+1SD) were considered to formulate the group diet. The calculated income over feed costs gain (IOFC, $/cow per yr) of having >1 nutritional group among the herds ranged from $33 to $58, with an average of $39 for 2 groups and $46 for 3 groups, when group was fed at average NE_L concentration and average MP+1SD concentration. The improved IOFC was explained by increased milk sales and lower feed costs. Higher milk sales were a result of fewer cows having a milk loss associated with low BCS in multi-group scenarios. Lower feed costs in multi-group scenarios were mainly due to less rumen-undegradable protein consumption. The percentage of total NE_L consumed captured in milk for >1 nutritional group was slightly lower than that for 1 nutritional group due to better distribution of energy throughout the lactation and higher energy retained in body tissue, which resulted in better herd BCS distribution. The percentage of fed N captured in milk increased with >1 group and was the most important factor for improved economic efficiency of grouping strategies.
Key words: stochastic, simulation, nutritional feeding, economics

INTRODUCTION

Grouping cows is a common practice that farmers use to manage their herds more efficiently. Farmers may use various grouping strategies to separate dry cows with remote or close expected calving dates, cows that have calved recently, sick cows, pregnant cows, and first- or later-lactation cows. Grouping addresses cow-specific needs (Cabrera and Kalantari, 2014). However, grouping lactating cows for nutritional purposes and providing them with more precisely formulated diets is not an extensively adopted strategy (Contreras-Govea et al., 2015), despite the fact that many studies have shown its possible economic advantage (Coppock, 1977; McGilliard et al., 1983; Pecsok et al., 1992; Williams and Oltenacu, 1992; Stallings, 2011; Cabrera et al., 2012). Reasons that farmers do not favor nutritional grouping can be attributed to facility management limitations (such as machinery and facilities), labor cost, difficulty in managing multiple diets, and the presumption of milk production loss associated with group changes (Contreras-Govea et al., 2013, 2015). Even for farms with multiple cow groups, which would have different nutritional needs, and the capacity to feed these groups differently, all cows are often fed with a common TMR (Contreras-Govea et al., 2015). Hutjens (2013) suggests that farmers may also be concerned about introducing errors in the formulation and delivery of rations with multiple nutritional diets. In a recent survey (Contreras-Govea et al., 2015), the top reason for dairy farmers not adopting nutritional grouping was its potential management complexity.

Total mixed rations have become an industry standard for feeding management, and many dairy farms are using just 1 TMR for all lactating cows despite major differences in nutritional requirements of dairy cows in different lactation stages (Allen, 2008). For example, 58% of Wisconsin and Michigan dairy sur-

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vey farms used the same TMR for all lactating cows (Contreras-Govea et al., 2015). The adoption and application of a single TMR as a common practice has resulted in more overconditioned cows in some cases, and greater nutrient excretion issues (Allen, 2009). Cows in similar lactation stages could have different nutritional requirements because of their productivity and genetic potential. When feeding only 1 TMR diet, it is usually formulated for high-producing cows to ensure these cows reach their full milk production potential, which results in overfeeding of lower-producing cows. Therefore, 1 TMR diet can result in more overconditioned cows, higher nutrient excretion in the manure, and increased costs of nutrient usage. A strategy to relieve this problem is adopting nutritional groups with more precise diets, which could improve herd health, decrease environmental concerns, and increase income over feed costs due to the better-tailored diet to the cow requirements in a group. More precise diets would also improve milk productivity (Bach, 2014).

Different strategies have been explored in the literature to determine the NE_L and CP concentrations of a diet for a group of cows, but in general, all used average milk production of a group as the basis for calculating lead factors, or the levels at which the diet should be formulated. These methods include, for example, the use of the 83rd percentile in each group (Stallings and McGilliard, 1984) or the use of differentiated levels according to several groups (Stallings, 2011). The 83rd percentile method proposes the formulation of the diet based on the 83rd percentile cow milk production in the group. This corresponds, approximately, to formulating the diet to 1.31 standard deviations (**SD**) above the average milk production for the group (1.31 lead factor; Stallings and McGilliard, 1984), assuming milk production in the group follows a normal distribution (St-Pierre and Thraen, 1999). The other method proposes formulation of diets based on group's milk production and number of nutritional groups such as diets for 30, 20, and 10% above the group's average milk production for nutritional groups 1, 2, or 3, respectively (Stallings, 2011). In the current study, we go beyond milk production as proxy by using the individual cow's daily NE_L and MP requirements to formulate more precise diet nutrient concentrations for the groups. Thus, in this study to formulate the NE_L and MP concentration of the diet for different groups, we evaluated factors of SD above the average daily concentration of requirements of the cows to explore their effect on the herd's outcome.

Simulation can be a valuable tool to explore the value of nutritional grouping, which is a complex decision with many interacting factors. Simulation can handle interactions among milk production, market price, herd size, energy offered and consumed, and consequent BW and BCS changes. Indeed, simulation models have been previously developed and used to quantify the economic and environmental impact of nutritional grouping for lactating cows in a herd (Pecsok et al., 1992; Williams and Oltenacu, 1992; Østergaard et al., 1996; St-Pierre and Thraen, 1999; Cabrera et al., 2012). In the current study, we advance the modeling of nutritional grouping by using a special type of stochastic Monte Carlo simulation approach, next-event scheduling (De Vries, 2001), which can be used to model individual cows daily for a limited period. The model simulates each one of the cows in the herd and estimates their daily body energy and changes in BW and BCS. Because a nutritional grouping strategy affects the energy concentration of the diet offered and consumed, our proposed grouping model updates body energy of the cows on a daily basis by rectifying the predicted amount of energy consumed and expended, depending on current BW and BCS, DMI, and dietary energy concentration. Detailed accounting of the total net energy (NE_L) consumed and used (maintenance, growth, production) by an individual is especially important in the net energy system, which the total energy intake needs to be accounted in terms of animals' products (milk, BW). We tracked all the inputs and outputs of energy within the nutritional grouping strategies studied. To the best of our knowledge, no previous study has included daily accounting of energy balance in a stochastic simulation model to explore the value of nutritional grouping in dairy cattle.

Thus, the objective of this study was to assess the economic value of nutritional grouping on 5 commercial dairy herds using a developed dynamic stochastic simulation model.

MATERIALS AND METHODS

Simulation Framework

A dynamic stochastic Monte Carlo simulation was developed to model individual cows after first parturition in a dairy herd. The next-event scheduling approach (De Vries, 2001) was used to schedule the stochastic events that could happen to cows during each reproductive cycle. First, a data set of all the cows in a herd and their current status were loaded (i.e., lactation number, day postpartum, reproductive status). Then, a list of possible stochastic events was scheduled for each cow at the beginning of the simulation and the list was renewed after starting their next lactation. These events included involuntary culling, death, pregnancy, abortion, dry-off, and parturition. For each event, a 2-step process was followed: (1) determining the binary