Grouping Strategies for Feeding Lactating Dairy Cattle

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Online Web-Based Application at http://dairymgt.info → Tools → Feeding

Dairy farmers might overfeed to a large proportion of animals in order to provide enough nutrients to the most productive group of cows when they feed the same ration for all cows. Splitting lactating cows in smaller groups with different rations will save money and increase the income over feed cost of the farm. Depending on the farm facilities and costs of extra management, grouping for feeding purposes could be a profitable decision if the estimated extra income over feed cost and possible savings is greater than the other incurred costs. A more precise ration will also decrease the excretion of nutrients and hence environmental impacts.

Strategies for Grouping Lactating Cows

There may be several possible strategies farmers could use to group lactating cows, formulate different rations, and feed differently to different groups of cows. The decision will depend on the individual cow's nutrient requirement expressed as Mcal/kg of Dry Matter (DM) and % of CP of DM, the number of animals, and the capacity of handle several feeding groups at the dairy farm level. One proposed stepwise approach is described below.

"This project is supported by Agriculture and Food Research Initiative Competitive Grant no. 2011-68004-30340 from the USDA National Institute of Food and Agriculture."

1. Get the farm data

A time-specific dataset of all lactating cows is needed. This dataset should contain the following fields as pieces of information:

Cow identification, parity, days after calving (DIM), milk production, and milk fat content. Optionally, for mayor precision, if available, cow's body weight could also be used.

2. Estimate Individual Cow Nutrient Requirement

Net Energy (NE)

Total NE (NE_{total}) of a lactating cow is the sum of the NE required for maintenance ($NE_{maintenence}$) and the NE required for milk production (NE_{milk}):

$$NE_{total}\ (Mcal) = NE_{maintenance} + NE_{milk} \quad [1]$$

The $NE_{maintenance}$ is a function of animal's body weight (BW in kg), NRC (2001):

$$NE_{maintenance}\ (Mcal) = 0.079 \times BW^{0.75} \quad [2]$$

The NE_{milk} depends on the cow's milk (kg) and fat production, NRC (2001):

$$NE_{milk}\ (Mcal) = Milk \times (0.36 + 0.0969 * (Fat\ \%)) \quad [3]$$

And then the NE per kg of DM is the estimated NE_{total} cow's dry matter intake (DMI):

$$NE\ (Mcal/kg\ DM) = NE_{total}\ /DMI \quad [4]$$

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Crude Protein (CP)

Total CP (CP_{total}) is also the sum of the CP required for maintenance ($CP_{maintenence}$) and the CP required for milk production (CP_{milk}):

$$CP_{total}\ (g) = CP_{maintenance} + CP_{milk} \quad [5]$$

The $CP_{maintenance}$ is a function of animal's BW, McGilliard et al. (1983):

$$CP_{maintenance}\ (g) = 104.78+0.73 \times BW - 0.00015432 \times BW^2 \quad [6]$$

The CP_{milk} depends on the cow's milk (kg) and fat production, McGilliard et al. (1983):

$$CP_{milk}\ (g) = Milk \times (4586 + 1036 * (Fat\ \%))/100 \quad [7]$$

And then the % CP per kg of DM is calculated using the estimated cow's DMI:

$$\%\ CP = (CP_{total}\ /1000)\ /DMI \quad [8]$$

Body Weight (BW)

Individual cow's body weight could be either measured or estimated. This is a function of cow's first and later parity, days after calving (DIM), and an average expected body weight by parity using the Korver function as described by van Arendonk (1985) and parameterized by Kalantari et al. (2010).

Dry Matter Intake (DMI)

Dry matter intake is daily calculated as a function of days after calving (DIM), body weight (BW), and fat corrected milk (FCM), NRC (2001):

$$DMI = (0.372 \times FCM + 0.0968 \times BW^{0.75}) \times (1 - e^{(-0.192 \times ((DIM/7)+3.67))}) \quad [9]$$

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Fat Corrected Milk (FCM)

Fat corrected milk is a function of the milk fat content of the milk with respect to the corrected level of fat, NRC (2001):

$$4\%\ FCM = 0.4 \times Milk + 15 \times (Fat\ \%/100) \times Milk \quad [10]$$

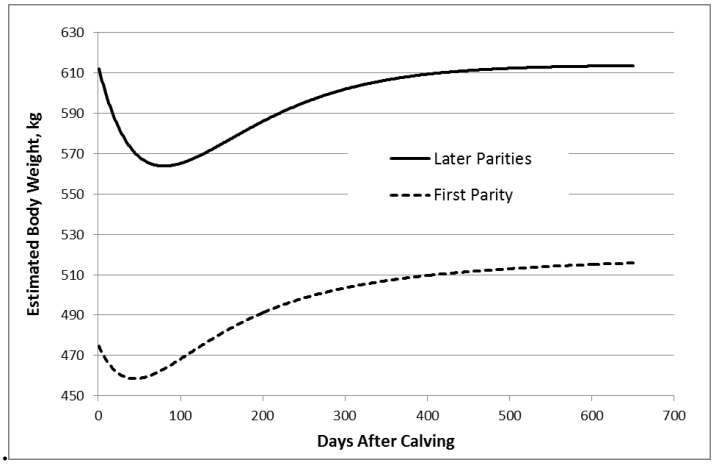

Figure 1. Estimated Cow's Body Weight (BW, kg) by days after calving (DIM) for an average 500 kg body weight for first parity and 600 kg body weight for later parities.

3. Determine Nutrient Requirements for a Group of Cows

Following the concept of *leading factors* (multiplicative factors) to adjust milk production (and hence nutrient requirement) to 83rd percentile (average plus one standard deviation; Stallings and McGilliard, 1984), it is proposed to use NE and CP requirements to 83rd percentile of the estimated requirement of the cows in a particular group as a baseline nutrient requirement for such group.

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4. Determine the Number of Groups

According to previous analyses (e.g., McGilliard et al., 1983; St. Pierre and Thraen, 1999) as well as empirical analyses within the proposed formulation here, there might be very little or no gain of feeding more than 4 different groups. Therefore, it is proposed to restrict the number of maximum groups to 4, and consequently, the decision is confined to manage 1, 2, 3, or 4 lactating groups of cows for feeding purposes. These depend on the facility and management of the farm. The number and size of the groups are pre-determined by the decision-maker.

5. Select the Criteria for Grouping Cows for Feeding Purposes

In order to demonstrate the value of better grouping criteria in comparison with farm used (if any) grouping criterion, it is important to perform an analysis that include both the grouping criterion used by farmers and grouping criteria found in the literature deemed as appropriate or commonly used by farmers. Four main criteria are believed to be critical: 1) Days after calving (DIM), 2) fat corrected milk (FCM), 3) merit, and 4) cluster.

The first criterion based on DIM consists on simply grouping cows according to their stage in lactation. This is popular among farmers as it is easy to manage, coincides or help with other management practices (i.e., reproductive tasks), and seems intuitive as cows in similar lactation stages would have similar nutrient requirements.

The second criterion of FCM prescribes that cows should be grouped based on their level of fat corrected milk. It seems also logic to think that groups of cows with similar FCM

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production should require similar amounts of nutrients and could have similar feeding ration.

The third criterion, merit, needs some additional calculations to the FCM. By definition, merit is $FCM/BW^{0.75}$ and it has been found to represent better than the previous methods the actual nutrient requirements of groups of cows (McGilliard et al., 1983).

The fourth criterion, cluster, seems to be the most efficient method to group cows (McGilliard et al., 1983, St. Pierre and Thraen, 1999). This method consist of using a "cluster" of cow's NE and CP requirements as the criterion to "enroll" cows in the same feeding group. Cows are grouped according to the distance existing between two cows in a space defined by NE and CP: Shorter distances group cows together.

6. Optimize the Cows Belonging to a Group to Maximize Income over Feed Costs (IOFC)

Price of NE and CP

Since no market value exists for NE ($/Mcal) and CP ($/kg), these can be deducted from referee feeds such as corn and soybean meal (SBM). The value of NE and CP can be calculated by knowing the NE (Mcal/kg), CP (%), and the price ($/kg) of corn and SBM and solving simultaneously equations 11 and 12:

Corn % CP + Corn Mcal NE = $/kg Corn Price [11]

SBM % CP + SBM Mcal NE = $/kg SBM Price [12]

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Cows Assigned to a Particular Group

Except from the option for no grouping (same ration to all lactating cows = one lactating group), the cows in each farm-defined group size and group criterion are found by an iterative process of searching for a global optimum with respect to maximum IOFC. The IOFC is the difference of the milk value minus the feed costs, both of which depend dynamically on the cows belonging to a group:

$$Max(\text{IOFC}) = \sum_{group=1}^{G} (IOFC_{group})$$

$$IOFC_{group} = (Milk_{group})(Milk\ Price) - (FeedCost_{group})$$

$$FeedCost_{group} = (83\%tileCP_{group})(CP\ Price) + (83\%tileNEl_{group})(NEl\ Price)$$

$IOFC$ = Income Over Feed Cost, G = total number of groups: 2, 3, or 4 [13]

7. Calculate and Compare the Net Return of Improved Grouping Strategies

A farmer may or may not be grouping lactating cows and feeding different rations.

1. If the farmer does indeed group cows for feeding and has no capabilities of doing more groups, there is still an opportunity for improving the grouping decision by either or both factors below:
   a. Select the right grouping criterion
   b. Optimize the animals belonging to each group

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2. If the farmer does indeed group cows for feeding and has capabilities of doing more groups, there is still an opportunity for improve the grouping decision by any or various of the factors below:
    a. Select the right number of feeding groups
    b. Select the right group criterion
    c. Optimize the animals belonging to each group
3. If the farmer does not group cows for feeding purposes, but the farm has capabilities of doing groups, there is plenty of opportunity to improve the grouping decision by:
    a. Performing 2, 3, or 4 feeding groups
    b. Selecting the right grouping criterion
    c. Optimizing the animals belonging to each group

Grouping Management Cost

Performing feeding groups adds to the farm cost because additional labor needed to formulate, prepare, and feed more feeding rations. This cost should be estimated and provided by the farmer since this is a highly farm-specific figure.

Milk Depression

It is also expected that cows moving from one ration to other ration, from a higher density diet to a lower density diet, will suffer a milk depression. Milk depression will also occur for social cow interaction adjustments when moving cows among groups.

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Once again, this should be estimated by the farmer since this is likely to be highly variable among farms. For convenience, this calculation can be performed as the multiplication of the expected time (in days) of milk depression times the expected amount of daily milk depression.

Costs Savings because of Grouping

Some producers use additives in all cows in a group. These additives are normally targeted for a type or class of cows (e.g., high producing early lactation cows). Therefore, adding feeding groups could save costs of not giving these additives to other feeding groups.

Net Return of Grouping Criteria

The Net Return can be calculated as the economic difference of IOFC of the optimal group criterion with the optimal number of feeding groups within the maximum number of groups possible in the farm and with the optimal type of cows in each group plus savings on additives (if any) minus the additional cost of management (if any) and the cost of the expected milk depression (if any).

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