Predicting Feed Intake in Lactating Dairy Cows: Using Theory in Practice

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Introduction

The amount of feed consumed by groups of commercial dairy cows is arguably the most important factor that influences their productive performance. Since cows cannot create energy, they are totally dependent on the feed that they consume to support their energy requiring functions of maintaining their body (maintenance), growing, gaining weight, growing a fetus, as well as producing milk and its components. If intake of feed is depressed by 5%, then the energetic sum of these functions **will** decline by 5%. Since maintenance, growth, and fetal energy requirements are very difficult for the cows' metabolism to modify, the impact of reduced feed intake is most often seen as a depression in milk and/or milk component yields as well as reductions in weight gain or increases in weight losses.

Ruminant nutritionists balance rations for dairy cows utilizing large and complex arrays of nutrients that include the types of proteins, types of structural and non-structural carbohydrates, macro- and micro-minerals, as well as fat and water soluble vitamins. These arrays depend upon maintaining optimal ratios among many nutrients as well as delivering absolute quantities of them to the rumen and/or intestinal absorptive site. However since cows require, in general, absolute amounts of nutrients to meet their needs, it is critical that the amount of ration that will be consumed is known in order to allow the appropriate nutrient density of the ration to be set. Thus if protein needs of the cows are 11 lbs/day and they eat 60 lbs of total dry matter (DM) per day, then protein required in the DM is 11/60 = 18.33%. However if the cows' actually consume only 58 lbs of DM, the required protein in the DM is 11/58 = 18.97%. Thus the first estimate made by most nutritionists is often DM intake.

Calculating DM Intake

While estimates of DM intake are commonly made, there is seldom much thought given to whether the method of doing so is consistent with the objective and indeed the exact nature of that objective is often left undefined. By far the most common method used to 'predict' DM intake is to define the average body weight (BW) of the cows, their average milk yield and its levels of protein and fat, and an estimate of body weight loss or gain. However in fact this approach is really a calculation, rather than a prediction, of DM intake. Since the net energy (NE_l) output of dairy cows is **defined** as the energy in milk, in body gain (or loss), as well as for maintenance, it is a matter of mathematics to calculate (not estimate) the DM intake of any ration with a known NEl density. For example, if the average NEl output of a group of cows is 40 Mcal/d and the average NEl density of the ration is 0.75 Mcal/lb of DM then the average DM intake is: 40/0.75 = 53.3 lbs DM per day. If the feeder says that this is not the actual value then either he or she is in error or one or both of your estimates is incorrect. The cows are not wrong.

Predicting Future DM Intake

The real DM intake challenge facing ruminant nutritionists is to predict the DM intake of a group of cows at some time in the future, often as the result of changing the ingredient and/or nutritive profile of the ration in the present. This challenge is considerably more difficult than calculating the current intake of a particular ration, as only some future information is known. Certainly most aspects of the ration in the future, in terms of its ingredient and nutritive profile can be defined, but only a few characteristics of the cows are pre-determined since many of the key factors, such as milk yield and composition, are what you wish to predict. What can be predicted will generally only include body weight (BW) and condition score (BCS), as well as stage of pregnancy (DP) and days in milk (DIM). While actual future milk yield and composition, as well as body weight gain or loss, are not known, desired levels are generally fixed. If a cheat is used, in which the desired milk production and composition is used to estimate DM intake of a defined ration then, in effect, the future has been made into the present, but with no confidence that the defined future ration can be consumed at levels sufficient to meet the cows' future nutrient needs for the desired level of production. In fact it is this DM intake that we wish to predict, in order to determine the potential production level of the cows that are offered it.

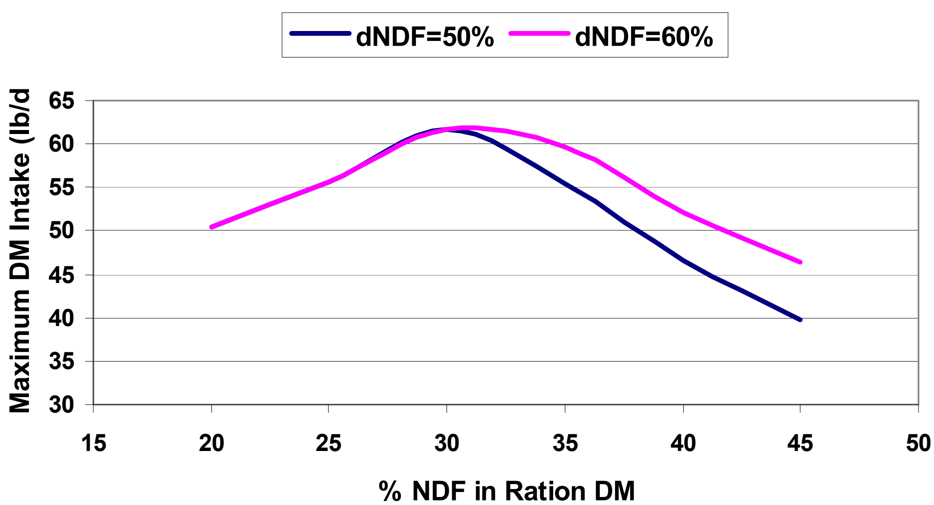
The way out of this conundrum is to recognize that actual DM intake of a group of cows at some point in the future cannot be predicted unless we can define all of the factors, and their values, that will impact DM intake at that time in the future. Neither seems likely to be possible anytime soon, since there are a myriad of animal and feed factors that may influence actual DM intake. However, it is possible to define the maximum potential DM intake of a group of cows fed a particular ration, in the future, based upon a limited number of ration and animal characteristics that are key to impacting DM intake and can be defined mathematically. This estimate will be broadly accurate overall, as it is based upon the premise that maximum DM intake is fixed primarily by characteristics of the diet while it is characteristics of animal and feeding management that prevent it from being achieved. The key factors that determine maximum potential DM intake include:

1) the level of structural carbohydrate in the ration (defined analytically as NDF),
2) the rumen fermentability of dietary NDF (defined analytically as NDF digested at 30 h *in vitro*; dNDF),
3) the level of non-structural carbohydrates (NSC) in the ration, and
4) the cow body weight and condition score.

Base Maximum DM Intake: The level of NDF, and its fermentability (dNDF), as well as the level of non-structural carbohydrate (NSC) in the diet are all key to determining the maximum potential DM intake of a ration. NDF tends to limit DM intake as its level in the ration increases, and reduced dNDF of that NDF will tend to further limit intake where NDF itself limits, due to the inability of the cows to chew and clear NDF from the rumen (Figure 1). In contrast, increasing levels of NSC only tend to limit DM intake where their levels in the ration are already high, due to accumulation of acids and other fermentation products in the rumen.

The key animal factor determining DM intake is size (i.e., BW), as larger cows can consume more DM. However the effective body size of the cow is influenced by the body condition score of the cows, as cows with low body scores are really larger cows hiding in smaller bodies, at least by weight, and so have higher DM intake potential.

Figure 1. DM intake as influenced by dNDF level of NDF for a specific case.



Known and Definable Modifiers of Base Maximum DM Intake: There are several known and mathematically definable ration and animal characteristics that tend to suppress DM intake to levels below the maximum potential. These factors include:

1) the dry matter level of the ration,
2) the fat level of the ration,
3) the lactation number of the cows,
4) the locomotion score of the cows,
5) the stage of pregnancy of the cows, and
6) the days in milk of the cows.

The DM and fat levels of the ration tend to reduce DM intake to levels below maximum potential levels. These effects differ, but are shown in Figures 2 and 3.

Figure 2. Effect of diet DM.

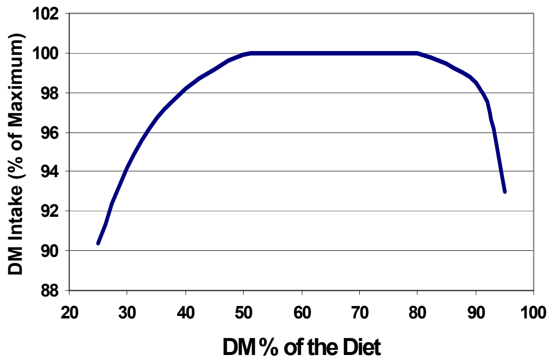
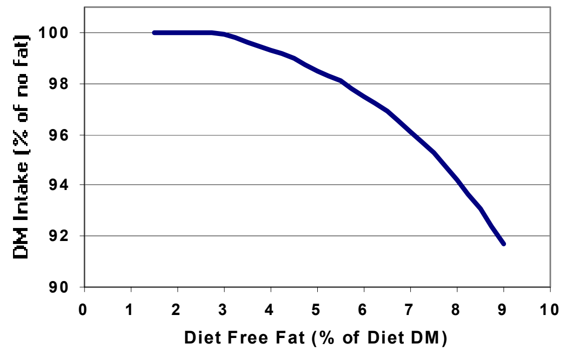


Figure 3. Effect of diet fat.



The lactation number of the cows, as well as their ability to walk (i.e., locomotion score), tend to suppress DM intake below the maximum possible. The general form of these relationships are shown in Figures 4 and 5.

Figure 4. Impact of lactation number.

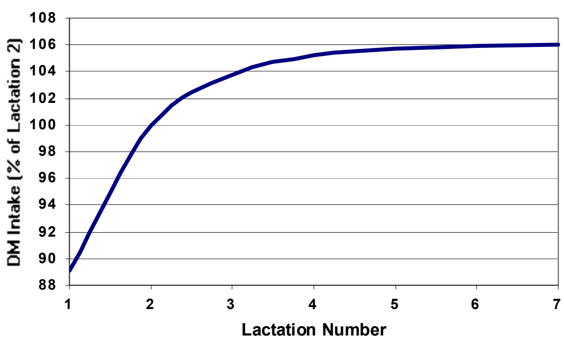
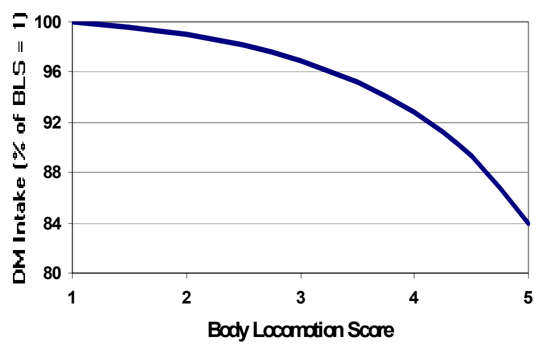


Figure 5. Impact of locomotion score.



However the stage of lactation and the pregnancy status of the cows are also known to influence DM intake of cows. The former most notably in early lactation, and the latter in later lactation. The general form of these relationships is in Figures 6 and 7.

Figure 6. Impact of days in milk.

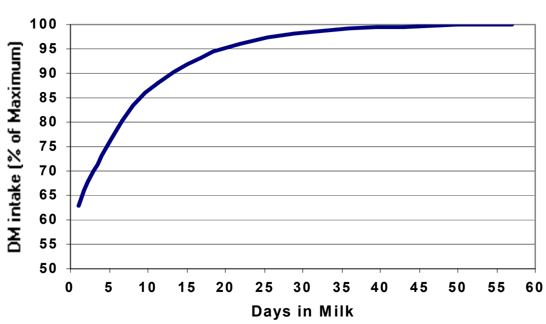
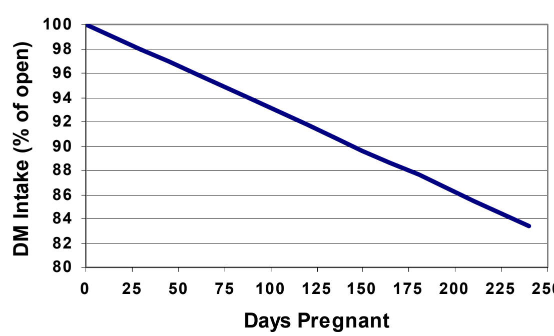


Figure 7. Impact of days pregnant.



While it is beyond the scope of this article to discuss how and why each of these ration and animal factors impacts DM intake, taken together they provide a basis for estimating maximum potential intake of any ration by any groups of cows as well as how that value will be impacted by known and mathematically definable factors that influence it. A spreadsheet that allows prediction of maximum potential DM intakes for different animal and ration situations is available at the spreadsheet section of this page:

animalscience.ucdavis.edu/faculty/robinson/spreadsheets.htm

Assessing the Impact of Unknown and/or Undefinable Modifiers of Base Maximum DM Intake: An interesting use of this approach is available for groups of cows for which the actual current DM intake is available. Here the actual DM intake expressed as a % of the predicted maximum DM intake yields an estimate of the extent of the depression in DM intake caused by general animal and feed management characteristics on the dairy that are not included as defined modifiers of the base DM intake. For example if the actual DM intake were >95% of the maximum potential DM intake, this suggests that there is little scope for increasing the DM intake of **that** ration by changes in management of the cows or feeding management. In contrast, if actual DM intake were <90% of the maximum potential DM intake, then there is a clear indication that the cows actual intake is being impacted by undefined animal of feed management factors such as disease, mud, or an abusive milker. In other words, it gives you a better idea of where to look for the problem, if there is a problem.

Overall

Prediction of the actual DM intake of a group of cows at some time in the future becomes inherently less reliable as that time advances from the present. However the maximum potential DM intake is definable at any time in the future based upon the premise that maximum DM intake is fixed primarily by characteristics of the diet while it is characteristics of animal and feeding management that prevent it from being achieved.