

Performance Monitoring of Dairy Nutrition and Feeding

Jim Barmore¹ and Greg Bethard²

Five-Star Dairy Consulting, LLC¹ and G & R Dairy Consulting, Inc²

Introduction

Feed is the single largest operating expense on dairy farms, while feeding and nutrition should be considered one of the most important variables behind successful production, animal health and profitability of a dairy. Annual feed costs per milking cow can average \$1000 to \$1200 per year, or \$100,000 to \$120,000 for every 100 milking cows. Despite this fact, only a minority of dairy farms closely monitor feed quality variation, feed mixing, inventories, feed bunk delivery, shrink, feed costs, and corresponding animal performance. The result is lost opportunity to improve cow performance and to better management expenses.

Feeding and nutrition is much more than just balancing a good ration, mixing and delivery of the feed, and removal of feed refusals. In a paper previously presented at this Conference (Barmore, 2002) discussing the fine-tuning of the mixing and feeding of high-performing dairy farms, there were four key goals identified. The fourth fine-tuning feeding goal addressed the need to have *on-going monitoring and use of records*. So, as a follow-up to the 2002 presentation, this paper will discuss specifics of “performance monitoring” that can be used to track and evaluate dairy nutrition and feeding.

On many dairy farms, the manager or employees responsible for feeding don't fully understand or appreciate the impact their role has

on the overall profitability and success of the dairy. The feed manager is responsible for handling over 50% of the variable costs of the dairy, which account for well over \$1,000,000 for dairy farms larger than 1000 cows and often equipment worth several thousands of dollars.

Clearly, implementing proper changes or improvements to a nutrition and feeding program first require that good timely data and information can be collected and interpreted. Historically, the primary focus of nutrition tracking and data collection have been done from a perspective of ration balancing “nutrient specification” and feed laboratory testing. In other words, the industry has given a lot of attention to tracking whether the ration is properly balanced for different nutrient pools, such as protein, rapidly degraded carbohydrates, and effective fiber, using accurate feed lab analyses. Although very important to a successful nutrition program, this might be considered too narrow of a perspective of the overall opportunities to monitor the nutrition and feeding program.

The concept of performance monitoring isn't new, but most of the discussions to date have centered on monthly, quarterly or even annual measurements by outside nutritionists, veterinarians, lenders, Extension, and other consultants. Although valuable, periodic performance monitoring does not usually sufficiently provide the timeliness of good daily data to optimize the management of a dairy. By gaining the interest and cooperation of on-farm

¹Contact at: 7905 Black River Road, Verona, WI 53593, (608) 833-1552, FAX: (608) 833-1035, Email: fivestardairy@charter.net

²Contact at: 4141 Peppers Ferry Road, Wytheville, VA 24382, (276) 637-6501, FAX: (276) 637-6503, Email: bethard@naxs.net



employees and management to engage in daily monitoring, the success of a dairy typically improves.

As illustrated (Figure 1), performance monitoring of the nutrition and feeding management should focus on four key areas, including: 1) **cow evaluation**, 2) **impact of facilities and environment on nutrition**, 3) **records evaluation and interpretation of data**, and 4) **feeding and feed costs**.

Ration Balancing and Nutrient Specification

Understanding and tracking the nutrient specifications balanced for in a ration are key components of performance monitoring of dairy nutrition and feeding. However, there have been other proceeding papers (VandeHaar, 2002; Weiss, 2004) that have addressed this, and the topic will not be considered in this paper. An area of ration monitoring rapidly coming to the forefront due to environmental considerations is phosphorus and nitrogen management. Although phosphorus monitoring of rations has received considerable attention, better nitrogen management and monitoring of the ration nitrogen input/output must become a higher priority of all nutritionists. This will require a better understanding of the existing research on different nitrogen and amino acid pools, and how nitrogen can be managed through nutrition and feeding adjustments.

Monitors Versus Report Card

As an industry, we have utilized the computer to process and calculate a wealth of data that pertain to the dairy. We have developed many benchmarks, and have typically provided a “report card” that suggest past success or failure. In general, report cards do little to predict future outcomes, and more importantly, are often too slow to let us know there is a serious problem. Aggressive and successful businesses are more interested in where they are going rather than where they have been.

Still, our industry is overloaded with benchmarks that show past performance and historical perspective. Although benchmarks and report cards have value in certain instances, they do not necessarily provide meaningful information to help a dairy navigate and improve the business over the upcoming weeks and months.

As opposed to a report card, we try to develop “*monitors*” to assess dairy performance. What does the word “monitor” mean as applied to dairy records? As a verb, it means the process of tracking parameters to detect change or lack of progress. As a noun, it is a specific parameter that is routinely measured. Why should we monitor records on a dairy or heifer operation? There are really 3 reasons to monitor:

1. Evaluate the impact of a management change,
2. Detect an undesirable trend or result, and
3. Motivate change.

Management changes include feeding changes, grouping changes, environment changes, etc. Before any management change is implemented, the business should know how to evaluate the response. The business should have knowledge of past performance and the ability to measure future performance with the appropriate parameter.

It is important that questions are asked first before data parameters are utilized. For example, a question may be, “Is fertility in my herd declining this summer?” Which parameter(s) would appropriately answer this question? It makes little sense to monitor a parameter and then decide what questions it may answer.

Monitoring data requires time and effort. Someone must collect the data, and then the data must be analyzed and interpreted. If this process does not result in discussion and/or action, then why

bother? Indeed, the goal of monitoring is to find areas where changes can be made to improve the dairy business. Monitoring is a waste of time and effort if decisions or management interventions do not result.

In summary, monitors should:

1. be proactive,
2. be readily measurable,
3. impact improvement and profit,
4. minimize variation, bias, lag, and momentum, and
5. result in discussion and action.

Records Evaluation and Data Interpretation

The computer has created a business world that is overwhelmed with information and data, yet often there isn't a clear understanding of how to properly collect and interpret good data, with the net result being bad decisions being made. This happens even though there are "lots of data". Before deciding to collect "more data", there are three steps that are recommended:

1. Clearly define what you are trying to measure, specifically defining the numerator and denominator if a calculation is involved.
2. The need is for "good" data versus "more" data; good data only can be generated if it's easily compiled, it is actually the proper data for the question being addressed, and is it timely.
3. There must be appropriate interpretation and discussion of the data, in a timely fashion, with the appropriate employees and advisors having agreement on management adjustments that will be taken because of the data interpretation.

There are several important principles of data interpretation and performance monitoring that must be considered to minimize misinterpretation

of the data. Specifically to managing a dairy, the phrase "numbers don't lie" might be better rephrased as "numbers don't lie if properly interpreted in the context of normal biological and process variation, and they are the correct numbers relative to the question at hand".

Averages versus distribution (variation)

The fundamental rule of nutrition and feeding is that "you never know the true value of anything" (Weiss, 2004a). There are reasonably accurate estimates of the nutrient requirements of production, good accuracy of the average dry matter (**DM**) intake for groups of cows, and for the average nutrient composition of the feeds being fed. However, there will always be biological and process (i.e. mixing and sampling feed) variation that will occur that can cause the actual situation to be different from what the "averages" are indicating. Does this mean that due to normal variation we should give up on monitoring nutrition and feeding management ...absolutely not! However, variation, and proper interpretation of data must be understood and addressed. As a starting point, Weiss (2004a) does an excellent job of discussing how to understand and manage feed ingredient variation.

We first need to think of feeding and nutrition in terms of the probability of an outcome rather than an absolute number. In other words, how confident are you that the number you are working with actually represents the true situation? In simple terms, knowing the distribution of data around an average allows the distribution to be used to determine how much confidence you should have when using an average value. The more variation, the greater the distribution and the less confidence that the average might truly represent the current situation. For another perspective on how distribution can be used in monitoring nutrition, one might also think of "*manufacturing a ration*" rather than balancing a ration, given that variation

and process control systems are much better recognized and understood in manufacturing industries.

Variability, or *lack of consistency*, is a dimension of risk and must involve monitoring of the nutrition and feeding on dairy farms (Fetrow, 2001). There inherently always will be some variation in outcomes on a dairy when we are dealing with biological units...or cows! Making milk is a manufacturing process. In any manufacturing process, there will be some degree of variability when inputs are put through a process. Cows fed the same ration will differ in their milk production, with an individual cow varying in production from day-to-day. Variation makes operating a dairy more difficult and less profitable because the outcome of a process (e.g. mixing feed) is not precisely known.

The unpredictability of a process (caused by variation) makes troubleshooting and planning of future outcomes more difficult. For example, either not having any mixing or feed intake records or having records with a tremendous amount of day-to-day variation makes the monitoring of the impact of the nutrition program on cow health and production very difficult. Variation in the predicted feed intake or other nutritional parameters can be thought of as deviation from the target points or goals, which obviously impacts the outcome. Without records, or a monitoring system, the variation cannot practically be measured or managed.

Lack of consistency in the day-to-day feeding and bunk management creates challenges associated with normal healthy rumen function and animal health. The idealistic rumen environment to maximize production and feed efficiency would be “steady-state” conditions. Biologically and practically speaking, striving for steady-state rumen conditions isn’t realistic, but the point to be made is reducing variation in the feeding can significantly improve cow performance by improving rumen function and digestion.

The best-managed, and typically most profitable, dairy farms seek ways to reduce variation and to better understand what is “normal variation and patterns” in daily processes. Dairy farms that can create consistency through better processes will improve their ability to plan and improve management. Daily monitoring of several aspects of the feeding and cow performance will allow quicker adjustments to be made as needed. The answer to getting started with improving variation in the feeding lies in implementation of good management plans with supporting monitoring systems. **Day-to-day consistency and monitoring of the cows, feeds, mixing, bunk management, and feed costs are key drivers of profitability on well-run dairy farms!**

Meeting specifications versus risk management

Producing milk and running a dairy means dealing with a biological manufacturing system (i.e. cows, people, and weather). It’s unrealistic to say that with a biological manufacturing system that we’re going to consistently meet exact specifications like might be considered in the manufacture of a car, textile, or other similar object. Rather, a preferred method of monitoring on a dairy is to collect and interpret data that will allow a better probability of predicting a positive outcome and allow doing this on a more frequent basis. Simply said, through the use of daily monitoring, we want to increase the number of times and probability of making good decisions through the use of good data and minimize the number of errant or bad decisions. Completely eliminating the bad decisions and unpredictable events (having to feed lots of low quality corn silage because of excessive rains) due to the biological nature of the dairy industry isn’t possible, regardless of the level of monitoring implemented. We aren’t trying to meet exact specifications as are other industries, rather trying to maximize the probability of making good decisions through the use of monitoring.

Accuracy versus precision

Using data to monitor performance generates discussion on how close to the target goals should a manager expect performance to be in feeding, fresh cow performance, milk production, and other measurable parameters. When working with cows and people, and dealing with the unpredictability of weather, it's important that performance be evaluated in the context of being "accurate" relative to the target goals, versus trying to be "precise" or exact. Lets use an actual "bullseye target" analogy, with circles that constrict towards center and hitting the bullseye being the indicator of greatest repeatability and accuracy. Accuracy can best be represented as consistently hitting within or near the bullseye, with no stray hits outside the innermost circle. Precision on the other-hand could be represented as time and time again hitting the exact same spot on the target. Expecting to hit dairy performance targets with precision simply isn't realistic. Rather the focus when monitoring nutrition and feeding performance should be to have excellent accuracy and not be concerned that data repeat with precision.

Normal versus abnormal variation

There will always be variation around an outcome; the key is to establish what is considered "normal" variation and monitor for the outliers or data that signal there is something abnormal going on. An example of this might be the normal daily variation that will be seen in fat test when taken daily on multiple loads of milk from the same dairy. We probably shouldn't concern ourselves with a fat test bouncing around from 3.4 to 3.6% between daily loads due to normal variation associated with time of day of milking and analytical variation with testing milk fat. However, if a pattern over multiple days of average daily milk fat tests had been consistently running from 3.50 to 3.55% and suddenly the daily average drops to 3.40% for three consecutive days, this clearly would be a signal that

something needs attention. The key is knowing the variation pattern and watching for "outliers" to the pattern. There will always be biological variation, and the pattern of this normal biological variation must be established. This can only be done with daily monitoring and collection of good data.

With good data, upper and lower limits can be set when data falls outside normal variation. These outliers are often referred to as signals or "flags" that intervention may be needed. An example might be the number of days that animals spend in a close-up group prior to calving. With proper monitoring, we can focus on average days in the pen, distribution of the average number of days in pen, and most importantly, the metabolic incidence rates associated with the animals that fall outside the targeted upper and lower limits (i.e. 18 to 24 days target distribution with the average days in the pen target being 21 days). Days in the pen will vary, looking at abnormal variation is the key!

The average, or central tendency of the data, likely is not the only acceptable outcome, but rather a range within normal variation. Often if three data points are near the upper or lower limits, this might be considered a signal that further investigation or intervention is needed. Usually, intervention based on a single outlier must be carefully considered when working in a biological system. One more key point on abnormal variation - remember that "abnormal variation or data" might actually be a good indicator, such as a cow being in heat thus her walking pedometer activity for a given day is very high and becomes manageable outlier data.

Statistical process control

There currently is a lot of interest and discussion of how to apply well proven statistical process control (SPC) principles on-farm to allow better monitoring and interpretation of farm generated data. Statistical process control is a method of interpreting time-series data using a

statistical process, which has been widely adopted across other industries and is commonly used in poultry and swine businesses. The general principle of SPC is to have ample good data collected on a regular basis that generates a historical perspective and “normal” pattern to the data. Statistical process control then is looking for irregular data patterns or “outlier data” that might be interpreted as a management issue that may need addressing. The underlying concept behind using SPC is to create more reliable processes and outcomes, with the intent being the ability to generate consistent results under all circumstances. Herein lays the potential blind spot of the dairy industry trying to fully embrace SPC type management on dairy farms. Let’s remember, we are dealing with a biological manufacturing system (cows, people, and weather).

The tradeoff of aggressively striving for more reliable systems when dealing with a biological based business is that these same systems may become less accurate or valid to what is trying to be accomplished. Just because a process is very reliable, or repeatable over and over, doesn’t mean it is necessarily meaningful or accurate. Adding “gut feel” and utilizing the craft and skills of employees to interpret the often changing situations of the cows and feeds may actually deliver more “accurate” results. Think of this as “reliability versus accuracy”.

Yes, dairy farms will benefit from more reliable processes, such as feeding where the results are more consistent (ration crude protein varies very little from day-to-day). But, what if the cows are suggesting based on observational factors that the accuracy of the ration relative to rumen function, milk production, and manure consistency isn’t very accurate (simply put “not getting the job done”), then what good is having very reliable results? Accuracy and reliability are a constant “push-pull” concept in data management. Producing accurate and repeatable results on a dairy requires that both qualitative, as well as quantitative, data be utilized, and dairy farms would be wise to think this through

before implementing a SPC monitoring system. A good example of this might be fresh cow monitoring and how utilizing temperature monitoring (quantitative) along with visual appraisal for “attitude and appetite” (qualitative) might be the best system. Standard process control systems typically address only the quantitative side of the picture.

Too much data versus relevant data

Too much aggregated data, from too many animals, summed over too many pens will tend to limit the value and relevancy of the information. The net result is the question at hand might not be correctly answered. An example of this might be knowing average DM intake for a herd, rather than knowing the DM intake for a specific pen. If looking at herd feed intakes, rather than pen intakes, because the denominator includes fresh cows, 1st calf heifers, possibly sick cows, and cows of all stages of lactation and production, the data are too broad and really doesn’t tell you anything about feed intake and energy balance for the cows in early lactation. With any data, it’s critical that both the numerator and denominator be known and appropriate for the question being asked.

Two dots don’t make a line

The opposite of too much data is not having enough data, yet falling into the interpretation trap of over-analyzing limited data, implying that it actually means something. Simply stated, it takes at least three data points to create any resemblance of a line with specific direction. If there are only two data points, the information could be completely misleading as to the true direction. An example of this might be having two displaced abomasums (DA) in a row...does this really mean there is a pattern or an issue with DA? Maybe or maybe not. However, if there are 3 to 4 DA in a row, this is a data line that is likely pointing in a direction that warrants investigation and/or intervention into what might be causing the DA.

Benchmarking versus monitoring

Benchmarking is a very common term and practice used across industries, including the dairy industry comparing peer results to performance at a given location. Benchmarking is always of interest because it looks at the “competition” and helps assess where a business stands relative to its peers. This will always be an important aspect of business analysis. However, there is big watch out with using benchmarking to monitor performance on a dairy.

The only time that benchmarking should really be used to make specific management decisions and changes is when clearly the benchmarks being compared have been calculated with the same exact definition for the numerator and denominator. A simple example might be comparing the retained placenta (**RP**) rate between three different dairy farms, where the dairy farms all use a different time period and/or method to define what actually constitutes a RP. Dairy A might only have a RP incidence rate of 6%, while Dairy B has a RP incidence rate of 9%. Knowing this information may not accurately indicate which dairy actually has the better fresh cow program. Clearly, this might have very limited value on a given dairy versus daily monitoring of fresh cow performance and taking timely and appropriate action for each and every RP that does occur.

Monitoring versus on-farm experiments

There is a common fallacy that if a dairy runs a feeding trial or experiment on their farm that the data and information will provide better insight to whether the feeding practice should be implemented. The fallacy of this is that relatively imprecise data measurements (always the case on individual data gathered on-farm due to all the biological normal variation) when added to a set of relatively precise (controlled research data) will actually improve the accuracy of the overall data set. This is simply false!! This is not to imply that

on-farm implementation of new practices and changes shouldn't be monitored...of course they should be! However, the monitoring should be focused on determining if the implementation of the technology or change is a good fit for the dairy, and whether by adopting the technology, there is a trend and pattern towards a more improved cash flow and long-term profit. When trying to answer whether the biology and science is sound behind an adopted technology or management change, only controlled research should be used to answer the “why and how does it biologically work” questions. Use on-farm monitoring to answer the “does it fit” and “does it appear to be improving cash flow and long-term profitability” questions.

Problems With Parameters

No parameter is perfect, although some are better than others. Parameter problems can be categorized as follows (Fetrow et al., 1997; Eicker et al., 2002):

1. Variation,
2. Momentum,
3. Lag and
4. Bias.

Variation results from one number having a large impact on the result. Data analysis for small herds is often limited for this reason. For example, suppose in one week that a group of 10 cows were palpated for pregnancy, and 4 were checked pregnant. Suppose the next week that another 10 cows were palpated, and 3 were pregnant. The numbers would suggest that palpation pregnancy rate dropped from 40 to 30%. This is a 25% reduction in palpation pregnancy rate. Did the dairy really get 25% worse?

Momentum is when too much time goes into the calculation, making changes difficult to detect. Large changes in performance are not detected quickly if there is too much momentum.

Rolling herd average, days open, calving interval, and average milk peaks are examples of parameters with too much momentum. Rolling herd average is the classic example of a number that is very slow to change, since a years worth of data goes into the calculation.

Lag is the time between when an event occurs and when it is measured. Age at first calving is a parameter that has significant lag. By measuring age at first calving, we are measuring an event that happened 9 months ago (conception). Although a heifer grower may want to record age at first calving for a report card or for marketing purposes, it has no value as a monitor.

Bias occurs when data are ignored or not included in the calculation. This includes using a subset of the herd or not accurately recording data. Conception rate is a good example of a parameter with bias. Suppose a dairy has 100 cows come into heat in a give 21 day period. The dairy farmer is confident that 50 of the cows are in good heat and will conceive, but they are not sure of the other 50. If only 50 are bred and 40 conceive, the records would indicate an 80% conception rate (40/50). If all 100 cows were bred and 60 conceived, then conception rate is 60%. If conception rate were the parameter used to monitor success, the first alternative would be optimal. However, the latter example with a lower conception rate resulted in 20 more pregnancies!

What Should Be Monitored?

Traditional monitors include rolling herd average, milk peaks, days open, calving interval, age at first calving, etc. Previous discussion tells us that these parameters are worthwhile as report cards but of limited use as a monitor. If these numbers get worse, the dairy has likely had a problem for some time.

We need to monitor parameters that will quickly tell us when a management intervention is warranted. As suggested earlier, there are four key areas that should be considered for performance monitoring of the nutrition and feeding management, including: 1) **cow evaluation**, 2) **impact of facilities and environment on nutrition**, 3) **records evaluation and interpretation of data**, and 4) **feeding and feed costs**.

To begin with, what questions should we be asking when we walk on a dairy? What questions address whether the feeding program and nutrition are working? Here are some questions and thoughts pertaining to each question:

1. Are the fresh cows doing well?
2. Are cows getting pregnant?
3. What are culling patterns telling us?
4. How is fresh cow and overall herd health?
5. How are the “good” cows performing?
6. How many “bad” cows are there?
7. How are the first lactation heifers doing compared to older cows?
8. By pen, are feed intakes meeting targets and how much variation is occurring?
9. What is the pattern for milk fat and protein?

Are the fresh cows doing well?

Monitors of limited value include average milk peaks in the herd, or any other “average” that applies to cows that calved over different time periods. Better monitors include calving disorders as a percent of calvings, milk weights during specific time periods during the first 60 days fresh (requires daily milk weights), first test milk weights from last test day, and 30- and 60-day cull rate [number of cows left less than 30 and 60 days-in-milk (**DIM**) divided by calvings].

Are cows getting pregnant?

Monitors including days open, percent of herd pregnant, and calving interval are of limited value. In asking the question, we are most concerned with the open cows in the herd, and the rate at which they are conceiving. The most appropriate monitor is 21-day pregnancy rate, which is the number of pregnant cows every 21 days divided by the pregnant-eligible pool [cows beyond the voluntary waiting period that are not Do Not Breed (**DNB**)]. The rate at which cows are resynchronized is also important.

What are culling patterns telling us?

Overall cull rate is a poor monitor to answer this question. Two additional questions further refine the issue: are too many fresh cows leaving and why, and are the cows that need to be culled leaving? Calculating a 30-day (or 60- or 90-day) culling rate, as previously described, will answer the first question. Quantifying the number of “bad” cows or “DNB” cows will address the second question. Any cow that is open >100 DIM and with less than 35 lb/day of milk is a “bad” cow in our estimation when other animals are available to trade-up and fill a necessary stall.

How is fresh cow and overall herd health?

This is a somewhat vague question that can encompass many areas and will vary depending on the dairy farmers ability to detect, define, and record incidence of disease on a consistent basis. Number of cows in the hospital pen, death loss, cows shipped, and disease incidence rate will provide some insight. Visual observation of the herd, including general appearance and condition of the cows, locomotion status, manure appraisal, and cud chewing, may provide additional insights. Percent born dead (dead on arrival; **DOA**) for cows and heifers calving over a given time period is a useful monitor of calving problems and the work being

done in the maternity area. Other more subjective measures may be useful for some dairy farms, such as scoring calving difficulty and assistance provided.

Metabolic disorders should be tracked as a percentage of calvings over a give time period. For large dairy farms, this time period may be a week or month. For small dairy farms, this time period may be quarterly, semi-annually, or annually. It is useful to compare first lactation disorders separately from older cows. All dairy farms do not record metabolic disorders in a similar manner, so they are difficult to compare or benchmark. For example, what is the definition of an RP? Is it a retained fetal membrane soon after calving, 24 hours after calving, 48 hours after calving, or only when a cow goes to the hospital? Incidence of DA is more straightforward. Milk fever incidence can be impacted by the aggressiveness of the herds person in the fresh pen. Ketosis is very subjective and most difficult to benchmark. Having said this, some reasonable goals are less than 3 to 4% DA, less than 10% RP, and less than 1 to 1.5% milk fever. Season and environment will obviously impact these numbers.

Are the “good” cows performing?

Which are the “good” cows? Recent milk peaks or production for cows in the earlier stages of lactation are worth monitoring to evaluate how the “good” cows are milking. The percentage of cows over 100 lb/day of milk may be meaningful, along with the “ceiling level” of milk production or the top level that cows are achieving under current feeding and management conditions.

How many “bad” cows are there?

Every dairy should have its own definition of a “bad” or unprofitable cow. If not, they should. Once the criteria for a “bad” cow are established, is the dairy removing these cows from the herd or are they holding onto them? For most dairy farms,

cows that are >100 DIM, open, and <35 lb/day of milk would be “bad” cows. Criteria for a cow to come a DNB should be clearly defined by the management team.

How are the first lactation heifers doing compared to older cows?

Mature equivalent (ME) production is an attempt to correct milk production for age, among other factors. Comparing 305-day ME for heifers and cows provides a report card for how heifers have done. First or second test 305-day ME projections provide more timely data and provide a sense of direction of how fresh cows are doing relative to previous points in time. Both reproduction and health data should always be evaluated based on lactation number, specifically looking at differences in 1st lactation heifers relative to cows.

How are feed intake levels and variation by pen?

Knowing DM intake and the variation around the average intake by pen have several advantages to nutritionists and others managing herd health. Typically, higher intakes will result in better milk production and energy balance of the cows. However, feed efficiency may actually suffer with higher intakes, indicating the importance of knowing intake along with milk production by pen (Linn, 2004; Hutjens, 2005). Possibly more important than knowing the average DM intake by pen might be knowing the amount of variation in intake within a pen. Dry matter intake will vary from pen movements, weather, forage quality, and numerous other factors. Consider that feed intake is not static even when these variables are relatively constant, and the “normal variation” must be established as the criteria in which the monitor is being measured against. In a commercial dairy setting, we don’t believe it always is accurate to impose our human “24-hr day” system of evaluating a cow’s DM intake pattern. It might be more telling to evaluate intake

patterns in slightly longer intervals, such as 48 hrs, to assess normal versus abnormal variation.

What is the pattern of milk fat and protein?

Milk fat might be considered a “standard” in the industry for monitoring nutrition and feeding. Although valuable, it’s of both authors belief that this is often misinterpreted and misused in the industry in terms of evaluating the true status of rumen health and energy status of cows and would best be carefully interpreted. The ease of milk fat data collection clearly suggests that it should be used as a monitor on all dairy farms, but with careful interpretation. Milk protein and milk urea nitrogen as monitors have been well discussed in many other papers and will not be addressed here.

Cow Evaluation

Considerable time is spent in the industry walking pens and evaluating what we see, smell, feel, and hear. In part, we want to determine if the cows are healthy and productive and to find problems that may exist with the cows. Each person has specific things they like to see when walking pens, along with subjective measures of rumen and cow health. Probably the most subjective of monitors recommended, these parameters and monitors combined with experience are valuable in performance monitoring of the nutrition and feeding program.

Cud chewing

This may be one of the most overrated monitors used in the industry because of the subjective nature. While widely adopted, many advisors to dairy producers promote the importance of monitoring cud-chewing as an indicator of normal rumen function. The limits of using cud chewing as a valued monitor comes from the subjective nature of how it’s measured and the limited accuracy of the “data”. Cud chewing can vary tremendously

throughout the day in relation to time of feeding, milking, lockup, and other activities that may interrupt their routine. Is “more” cud chewing always a good thing? One way to really get cows chewing more is to force them to consume some really low quality forage!

Just because a predetermined percentage of a group is not chewing their cud during a single walk-through, does this mean they are not healthy or productive? A good approach to consistently monitor cud chewing is to choose a spot and time to monitor and compare over different visits to the dairy. Another way to improve the accuracy of the data is to make an assessment of cud chewing on the entire herd, even though multiple pens may be involved. The milking parlor is an under-utilized place to monitor cud chewing – consider the location standardized across pens and all animals. In the parlor, within a few minutes of the machine being attached, cows should be relaxed and prone to chewing. In our experience, consistently high performing herds will achieve in excess of 50 to 60% of the cows in the parlor chewing at any given time post machine attachment. This figure often will approach 90 to 100% of the cows on a given side of the parlor, including during periods of heat stress if ample cow cooling is being provided.

Manure

This subject has been a popular topic in recent years, and a thorough discussion could fill an entire paper (Hall, 2003). Although a very subjective monitor, most nutritionists consider manure evaluation important, looking for consistent manure within a pen and little variation across the herd. Normal variation within a pen might be considered as 2 to 3% “too loose” and 2 to 3% “too stiff”, although every nutritionist has a different definition of “loose” and “stiff”. Loose manure can result from protein imbalances, irregular feeding patterns, forage moisture swings, acidosis, moldy and/or mycotoxin contaminated feeds, and sorting

among other items. Loose manure with bubbles, off-color, greasy appearance, or strong smell is a cause for concern and further investigation. It is not unusual for “just fresh” pens to have a higher percentage of animals with loose manure. Presence of mucus or small amounts of undigested feed in the manure is disconcerting to many nutritionists, but in practicality, it is not always a cause for concern. Some ingredients, such as whole fuzzy cottonseed or cracked soybeans, will almost always result in 1 to 3% of the seeds (by weight fed) passing into the manure undigested, yet these ingredients are staples in many successful dairy farms.

The key to manure monitoring is to realize that we are looking for “outliers” more so than the average composition. Washing of manure is of limited value to the authors, given the highly subjective nature of interpretation (Stone, 2005). Compared to low producing herds, high producing herds often have more mucus and small amounts of “undigested” feed in the manure, potentially from higher rate of passage.

Locomotion

The purpose of locomotion scoring is to evaluate foot health in a herd. Without formally scoring every cow, it is useful to watch cows walking to and from the milking parlor to evaluate foot health. Cows with a normal gait should place their rear foot in nearly the identical place the front foot just vacated. Cows should also walk and stand with a straight back. Quantifying foot problems is difficult in many situations, but overall as a monitor, this has a lot of merit.

Behavior

Understanding normal comfortable cow behavior is key to monitoring the performance of nutrition and feeding. Cows should always be relatively calm without getting restless or excited from someone walking in the pen. Pens of 1st calf

heifers will be more likely to become anxious from someone walking the pen. Cows should always be able to move about freely without slipping or falling. Cow behaviors in the pen that are appropriate include resting, eating, cud-chewing, drinking, exhibiting estrus, and walking to and from these activities, with all of these being done in a calm non-combative or competitive way. Other activities, including standing around, fighting, and nervous reaction to stimulus, can impair production and foot health. Normal cow behavior, regardless of temperature conditions or other factors, is key to success of a nutrition and feeding program.

Monitoring Facilities and Environment

Ever feel frustrated having a well-balanced ration being delivered and consumed by the cows, yet cow performance is not meeting expectations? Cow performance and health require excellent nutrition, as well as minimizing a cow's exposure to stress. Dairy facilities can have a dramatic impact on milk production. A dairy facility must create an environment that is ideal for cow comfort and normal cow behavior, while allowing the employees operating the dairy to produce consistency in day-to-day tasks.

Facilities should be designed to minimize travel distances, time standing, and slippage and poor footing. A good cow-friendly environment must also minimize heat stress, allow the cow the opportunity to rest comfortably in a stall when desired, deliver clean abundant supplies of water, and maximize the cow's opportunity to consume fresh feed without competition from other cows in the pen. Clearly, there often are bottlenecks in one or more of these facility-related areas that prevent the full expression of a quality ration and feeding program. **Don't ever overlook the impact that facilities might have on the performance of cows consuming a high quality ration!**

Research continues to help us better understand the interactions of facilities, cow environment, and cow behavior (Smith et al., 2002). A better understanding of how a high performing cow spends time eating, ruminating, and resting, and how these are impacted by environmental conditions allows development of better rations and feeding practices. Realizing there are distinct differences in cow behavior and needs with primiparous and multiparous cows in itself is important when evaluating rations and facilities. From an evaluation perspective, there also needs to be a better understanding of how much cow-to-cow variability there is in the key behaviors that comprise a cow's time budget.

Grant and Hill (W.H. Miner Agricultural Research Institute, Chazy, NY; 2005, personal communication) are finding large ranges in resting and rumination times of animals. This might suggest that evaluating the "average" cow behavior might provide limited information versus maybe looking closer at the "outliers and "signals" that small groups of underperforming animals within a group or pen might be showing. When these researchers stratified animals into two groups, those producing over 100 lb/day of milk and those producing less than 100 lb/day, the average resting time for the higher producing animals was 12.5 +/- 1.4 hr/day compared to 10.6 +/- 2.4 hr/day for the lower producing animals. **The resting time was nearly two hr/day greater for the higher producing cows.**

In a preliminary analysis of the data, regressing resting time against milk yield indicated that every extra hour of resting was associated with an increase in milk production of approximately 3.3 lb/day (Grant and Hill, W.H. Miner Agricultural Research Institute, Chazy, NY; 2005, personal communication).

Key areas of facility and environmental monitoring are listed below. Each of these areas, if

not properly managed, will hinder normal feed intake and amplify body maintenance requirements, with the net effect being lower feed intake and low milk production relative to the energy intake. Hutjens (2005) and Linn (2004) nicely discussed the concept of feed efficiency and environmental factors that can limit the conversion of consumed digestible energy to milk production.

Cow comfort and facility monitoring encompass much more than just the freestall beds and the bunk space. Consider the entire pen and milking center as the “environment”.

Facility and environment monitoring

- Proper air exchange and flow, with key areas being over stalls, in the holding pen, and parlor.
 - Heat abatement is a must on all dairy farms, which should include proper shading, use of forced air movement, and water cooling. Cows must be encouraged to maximize eating and resting time during warm conditions.
 - Waterers must be readily accessible, providing abundant clean water. Ideally each waterer should allow three or more cows to drink simultaneously without competition. Cow traffic should move freely behind the cows that are drinking in cross-overs. Provide water in route to/from the parlor when possible, providing 2 linear feet of breezeway water space per parlor stall for each side returning from milking (i.e. for a double-16 parlor, provide 32 ft of water trough space when possible).
 - Alleys, cross-overs, and walking surfaces must allow normal locomotion, while minimizing slippage. Improper concrete finish, lack of proper grooving, ice, slippery rubber surfaces, and excessive sloping can all cause locomotion issues. Don't underestimate the importance of proper grooving or newer rubber surfaces that can be overlaid on concrete to improve locomotion and foot health.
- Freestalls should encourage maximum resting time and ease of rising, while properly positioning cows to minimize soiling of the beds. Design and management of freestalls should consider the following:
 - Leveling of the bedding and refilling schedule,
 - Depth and dryness of bedding to ensure cleanliness and cushion,
 - Forward and side lunge space and ease of rising,
 - Neck rail placement,
 - Brisket board height and placement,
 - Loop design, mounting structure, and dimensions, and
 - Front and rear of freestall, head space and obstructions, and curb height.
 - Bunk space, manger height, headlock opening dimensions, and cow-side feed alley widths have a large impact on intake and nutrition performance.
 - Bedded packs must be kept clean at all times, providing adequate square footage per animal. Minimizing time on a bedded pack should be the goal for every cow, whether using a calving pack or sick cow pack. Lack of proper cooling, inadequate supply of cool water, and lack of fresh feed often are bottlenecks when managing bedded packs.

Stocking density and grouping are other aspects of facilities and the cow's environment that can have big impacts on performance. There are detailed discussions of these topics that can be referred to separately (Barmore, 2003; Robinson, 2004).

Monitoring Mixing, Feed Delivery, and Bunk Management

The process of taking feeds from storage, accurately weighing and mixing the feed, and then delivering the proper ration to the correct pen of cows seems rather straight forward. That is, until

we consider the moisture variations that can occur in forages (Stone, 2005) and other feeds stored outside, the changes that can occur regularly with forage quality, the difficulty in accurately weighing some ingredients, ease in which feeds can either be over or under-mixed, and the human errors that can occur throughout the feeding process for various reasons.

A high plane of nutrition consumed on a consistent basis has a tremendous impact on the overall success of a dairy. A key component of nutrition is obviously feeding and bunk management. Given the high variable costs associated with feeding and the impact of nutrition on herd performance and health, it hopefully becomes obvious that establishing a daily nutrition and feeding monitoring program will be financially beneficial.

Monitoring of the feeding program can be broken into two distinct areas, the first area being the parameters that the feeder and nutritionist closely monitor, and the second area being parameters that the owner/manager and nutritionist typically monitor (Barmore, 2001). Although there certainly will be overlap between these, it has been helpful to establish specific responsibilities with many of the monitors better suited for the person actually doing the daily feeding.

Parameters Monitored by Feeder

Mixing feed, delivery of feed, and bunk management can be quite comprehensive, including all aspects of determining the batch size, frequency of feeding, timing of feeding, feed delivery to the bunk, feed push-ups, feed stability and bunk-life, actual intake and recordkeeping, feed sorting, feed weigh-back management, and the bunk environment, including stocking density and manger design. Stated a lot more simply, *the goal is to provide a fresh, high-quality, non-sorted ration at all times, where cows can get feed when they want, in unlimited quantities, without*

competition from other cows with both feed and water available in a comfortable environment.

One of the greatest areas of feed variation that requires monitoring is with forages, whether ensiled or dry hay being fed (Stone, 2004). There are several parameters of forage and feed quality, along with total mixed rations (TMR) bunk management, where a feeder and nutritionist should work together to establish a monitoring system of these parameters that uses both a subjective and quantitative analysis, including:

- Moisture content of forages, other wet feeds, and the blended TMR,
- Smell and fermentation quality of ensiled feeds before feeding,
- Excessive wet or otherwise bad forage that needs to be isolated or discarded before mixing,
- Identifying feeds which are heating prior to coming out of storage,
- Particle length of forages from storage, after mixing, and in the bunk,
- Proper kernel processing of corn silage,
- Baled hay coarseness, stem texture, and mixing properties of the baled hay,
- Grain particle size.,
- Ingredient inventories adequate to complete the next day feedings,
- Proper appearance of blended protein or grain mixes based on the actual formulation,
- Occurrence of moldy feeds that need to be discarded,
- Level of refusals in each pen requiring removal before feeding,
- Accurate cow pen counts to determine batch sizes needed,
- Level of sorting assessed by comparing the fresh TMR relative to the refusals removed,
- Heating and secondary fermentation of the TMR that may occur in the bunk, and
- Frequency of TMR pushup and adequacy of

having TMR available the full length of the bunk at all times.

Have we as consulting nutritionists and veterinarians truly invested in training the proper people that have a key role in feeding management? Although several years ago, Bucholz (1999) pointed out the gaps in understanding recommendations between nutritionists and the feeders that were encountered in their Extension feeder training programs. Something as key, and relatively straight forward, as moisture determination had several breakdowns due to lack of understanding and clarity on the behalf of many of the feeders. This lack of understanding still exists on many dairy farms as we speak.

Accuracy of mixing

Knowing the accuracy of how ingredients are loaded into a mixer is important to minimize future mixing errors. From an expense management perspective, knowing the accuracy of loading and mixing is key. Some of the common tools used to determine the accuracy of loading and mixing are: 1) TMR nutrient analysis, 2) particle size evaluation, 3) marker or tracers blended and tracked, 4) hand-recorded feeding logs, and 5) use of software programs which interface with mixer scales.

A big potential advantage of implementing a monitoring program is the ability to better manage the consistency of the day-to-day rations being delivered. The key to improving mixing accuracy, feed inventory control, and reducing shrink and variation is setting up a well-understood and effective monitoring system for measuring feed disappearance charged against inventory. Many examples can be cited of a dairy that experienced a significant health challenge with fresh cows, or a dairy that lost a large amount of milk production and income over time because of errors that were being made in the mixing or feeding program, yet essentially no records were available to quickly and accurately determine

specific causes or to allow implementation of a better management plan.

There are several methods to monitoring and tracking the actual loading, mixing, and feeding process. Neither will one system fit all dairy farms, nor are any systems 100% accurate. Essentially, there are three ways to approach setting up a monitoring system, including: 1) using a simple “pencil and paper” system of recording, 2) using a combination of #1 and spreadsheets, or 3) using a computerized software program specifically developed for tracking and monitoring feeding and inventories that integrates with the scale on the mixer. Each of the systems has its own advantages, with clearly the future being with the radio frequency scale integrated feed management software programs that allow extensive data evaluation of the feeding system. For any of the systems used, determining forage inventories can be one of the more difficult steps. Forage storage capacity charts can be used to fairly accurately determine how much forage is in inventory based on measured compaction density and the size of the bunker or bag.

Feeding Parameters Monitored by Management

Are the feed costs acceptable?

Feed cost per cow per day is often used as the primary monitor of feed costs, but it is limited as a monitor for obvious reasons given that higher producing cows eat more feed. Feed cost per hundred weight of milk is a better measure of feeding economy and has some use as a report card but limited use as a monitor (Bethard and Stokes, 1999). Income over feed costs (**IOFC**) is a better monitor for short term decisions. As an example, consider two herds with varying production and feed costs but similar milk price (\$15/cwt). Herd A has low feed costs (\$2.95/day) and low milk production (65 lbs/day), while Herd B has higher feed costs

(\$3.40/day) and milk production (75 lb/day). Feed cost per hundredweight is \$4.54 for Herd A and \$4.53 for Herd B. However, IOFC is \$6.85 for Herd A and \$7.85 for Herd B.

This example illustrates several points. First, feed cost per hundredweight is not necessarily a good monitor. Second, benchmarking between herds can be very misleading. Feed cost per hundredweight is not adjusted for fat and protein content of milk, so herds with higher components will often have a higher feed cost per hundredweight, all else being equal. Some dairy farms will also include dry cow feed cost in the feed cost per hundred weight calculation, while other dairy farms will not. This can be a significant source of error when benchmarking feed costs among dairy farms. Generally, using both IOFC and feed cost per hundredweight of milk will provide a more accurate assessment of feed costs than either one alone, and certainly both of these monitors are better than feed costs per cow per day.

Since protein and commodities typically represent a large majority of purchased feed costs, closely monitoring and managing these costs can represent very large contributions to the year-end bottom-line. Without ever compromising quality, risk management strategies should be utilized in feed cost management that includes bids, contracting, and other price protection vehicles where appropriate. Cost of inventory and shrink are often underestimated when considering the types of ingredients and storage that best fit a given dairy. Regular monitoring of purchased feed costs should be implemented at every dairy.

There are other feed cost related questions to ask, depending on the goals and structure of the dairy. Many nutritionists want to know if cows are efficiently converting feed to milk. The milk:feed ratio (pounds of milk per pound of DM intake) is typically monitored to answer this question. This number does have some value as long as the context

of how it's interpreted is understood. Feed efficiency will vary considerably (Linn, 2004; Hutjens, 2005) depending on herd make-up (portion of herd that is heifers, days in milk for the herd, etc.), accuracy of measuring true intakes versus feed delivered, and actual milk, etc. shipped by pen.

Summary

Feed costs represent the single largest variable expense of producing milk. Many dairy farms have the ability to monitor and track inventories, mixing, and feeding but lack a well thought out system and plan. The economic incentives for creating such a plan are large. Often, when data are available, it's under-utilized or almost equally as bad misinterpreted. Collecting feed quality and ration variation information, along with feed intake and feed inventory information, allows a dairy team to more quickly uncover areas of needs to avoid issues that otherwise would arise with cow health, lost production, or higher than expected feed costs.

Experiences have shown that by establishing as part of a feeder's job description the expectations for monitoring feeding and mixing, and at the same time giving the feeder the monitoring tools, that significant reductions can be made in the variation that occurs from load-to-load or day-to-day. Reducing the variation in the rations delivered, while reducing feed shrink, are real opportunities available to the dairy producer for better managing a significant area of risk. Records and monitoring are always a key to improving and must be considered a key to building a better feeding management plan and reducing risk exposure.

Begin by making a commitment to improving the mixing and feeding management and monitoring the feeding process on a daily basis; speak to this commitment with employees and other professionals supporting the dairy. Understand the areas which contribute to the greatest variation. Clearly

communicate that feed inventory, feed removal from storage, mixing, and shrink along with bunk management are part of the feeder's responsibilities, including writing it into the job role and description. Provide on-going training for these same employees. Develop an organized, yet simple, monitoring program that will be embraced by the feeder, nutritionist, veterinarian, ag lender or accountant, and management team alike. Recognize the significant costs associated with variation and feed shrink that occurs in a feeding program, deploying the proper amount of resources in labor and capital to allow improvements to be made. Investment and changes in feeder training, proper feed handling equipment and mixers, storage facilities and bins, along with computer feeding software, often are solid investments with relatively quick returns. Set clear expectations with the entire dairy management team as to what the goals and commitments are for improving mixing, feeding variation, and feed shrink.

And don't forget to celebrate the success and improvements along the way!

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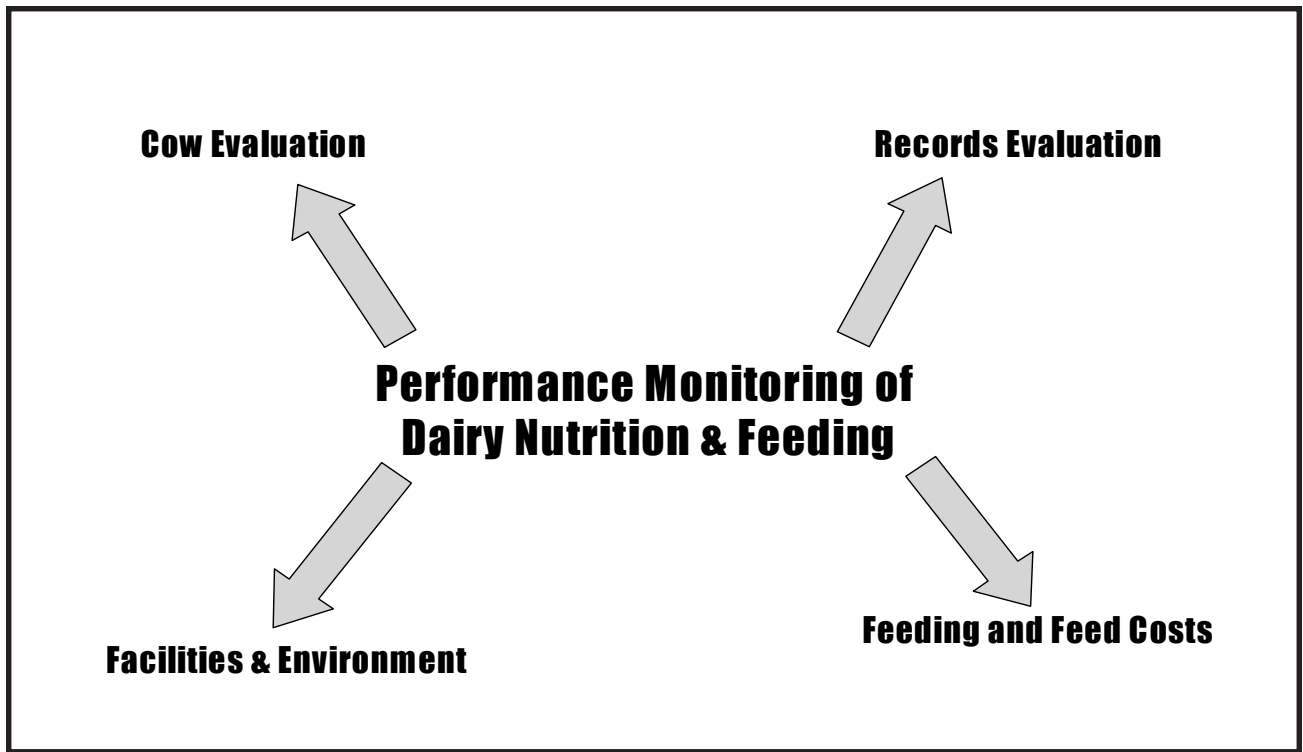


Figure 1. Four key areas for performance monitoring of dairy nutrition and feeding.