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## ***Lactobacillus buchneri* for Silage Aerobic Stability**

David K. Combs and Patrick C. Hoffman  
Department of Dairy Science  
University of Wisconsin-Madison

*Lactobacillus buchneri* is a bacterial inoculant approved for use in grass silages, corn silage, legume silage and high moisture grains. *Lactobacillus buchneri* has been demonstrated to improve aerobic stability of silages by reducing the growth of yeasts. The net result is that silages inoculated with *L. buchneri* are more resistant to heating at feed out (exposed to air) as compared to untreated silages.

### **What is *L. buchneri*?**

*L. buchneri* was originally isolated from naturally occurring aerobically stable silages. *L. buchneri* is a heterofermentative bacteria that produces lactic and acetic acid during fermentation. Silages treated with an effective dose (4 to 6 x 10<sup>5</sup> CFU/gram of fresh material) of *L. buchneri* have higher concentrations of acetic acid and lower levels of lactic acid than untreated silages.

### **How is *L. buchneri* different from other bacterial silage inoculants ?**

Most bacterial silage inoculants produce primarily lactic acid during the fermentation process. The most common lactic acid producing bacteria used in silage inoculants are *Lactobacillus plantarum*, *L. acidophilus*, *Pediococcus cerevisiae*, *P. acidilactici*, *P. pentosaceus* and *Enterococcus faecium*. These organisms have been demonstrated to increase the rate of pH decline during fermentation, decrease losses of silage DM, and in many cases, animal performance is improved. However, silage fermentation products produced by homofermentative bacterial inoculants sometimes can result in silage that is less stable when exposed to air than silages that have not been inoculated. This is possible because lactic acid produced by homofermentative bacteria can be readily metabolized by some species of yeast and mold upon exposure to oxygen.

When applied at the time of ensiling at the rate of 4 to 6 x 10<sup>5</sup> CFU per gram of fresh material, *L. buchneri* has been demonstrated to improve aerobic stability of high moisture corn, corn silage, alfalfa silage and small grain silages relative to untreated controls. The beneficial impact of *L. buchneri* appears to be related to the production of acetic acid. Although the precise mechanism has not yet been determined it is likely that aerobic stability is improved because acetic acid inhibits growth of specific species of yeast that are responsible for heating upon exposure to oxygen. In research trials yeast and mold growth in silage treated with *L. buchneri* has been lower at feed-out than for untreated control silages. Yeast and mold levels in silage inoculated with *L. buchneri* also do not increase as rapidly as in untreated controls when exposed to air. As a result, the temperature of silage inoculated with *L. buchneri* does not readily rise upon exposure to air and tends to remain similar to ambient temperature for several days, even in warm weather.

### **When would *L. buchneri* be expected to most effective?**

Treating silage with *L. buchneri* most likely would be beneficial under circumstances where problems with aerobic instability are expected. Corn silage, small grain silage and high

moisture corn are more susceptible to spoilage once exposed to air than legume or grass silage, and therefore may benefit more favorably to inoculation with *L. buchneri*. *L. buchneri* can also be applied to legume silage if aerobic stability is a problem. It should be remembered that high ambient temperatures, slow filling, improper packing, low surface removal rate and poor feed bunk management are all factors that can decrease aerobic stability of silage. It is likely that *L. buchneri* would improve aerobic stability in circumstances where untreated silage or silage treated with lactic acid producing bacteria have a history of heating at feed out. It is unlikely that *L. buchneri* will improve silage quality in situations where silage has a history of being aerobically stable at feed out. In fact, under such circumstances, the potential reduction in silage dry matter recovery due to the this organism's heterofermentative fermentation may actually make *L. buchneri* a less desirable silage inoculant than homofermentative bacterial inoculants. Producers should be aware however, that dry matter losses associated with spoilage occurring at the face of the silo are usually much greater than dry matter losses that occur while the feed is fermenting.

### **Does *L. buchneri* affect feed intake or milk production?**

Acetic acid can reduce feed intake in ruminants. It is not clear at this time whether enough acetic acid is produced in silages treated with *L. buchneri* to affect feed intake. We found in a recently completed lactation trial that feed intake and milk production were similar when cattle were fed total mixed rations containing untreated or *L. buchneri* inoculated high moisture corn. The corn inoculated with *L. buchneri* had higher concentrations of acetic acid and was aerobically more stable than the untreated corn. University of Delaware researchers have also reported that acetate levels were elevated in alfalfa silage and barley silage inoculated with *L. buchneri* compared to untreated controls. Milk production and feed intake were not different when dairy cows were fed TMR's containing either treated or untreated alfalfa silage, or treated or untreated barley silage.

### **What's the bottom line with *L. buchneri*?**

Forages and grains treated with *L. buchneri* at a rate of at least 4 to 6 x 10<sup>5</sup> CFU/gram of fresh material at ensiling results in silages that have elevated concentrations of acetic acid and lower levels of lactic acid than untreated controls. Yeast counts tend to be reduced in silage inoculated with *L. buchneri*. As a result, silage inoculated with *L. buchneri* resist heating when exposed to air, when compared to untreated silages or silages inoculated with lactic acid producing bacteria. Research conducted to date has not shown that animal performance is improved when cattle are fed silages inoculated with *L. buchneri*. Intake and milk production have been similar in trials where cattle have been fed diets containing either *L. buchneri* treated or untreated high moisture corn, alfalfa silage or barley silage. The bottom line is that it appears that inoculation of silage with *L. buchneri* has the potential to dramatically improve aerobic stability of ensiled feeds and may significantly reduce feed waste in circumstances where heating and molding of feeds are an ongoing problem. The economic benefit of using this product will depend on how much feed can be saved by reducing losses associated with aerobic instability.

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# Monitoring and Managing Feeding, Inventory, and Shrink

James A Barmore, M.Sc., PAS<sup>1</sup>  
Technical Service Specialist  
Monsanto Dairy Business

## **Economic Opportunity and Implications**

Feed is the single largest operating expense on dairy farms, and should be considered one of the most important variables behind successful production, animal health and profitability of a dairy. Despite this fact, only a minority of dairies closely track feeding, feed inventories, and closely monitor feed shrink.

Annual feed costs per milking cow can average \$1000 - \$1200 per year, or \$100,000 - \$120,000 for every 100 milking cows. Feed shrink can vary considerably from dairy to dairy depending on ingredients. Shrink on individual ingredients has been reported to range from 0.5% to 20% (Dutton, 1998; Gaige, 1998), with forage shrink often well in excess of 20% (Holmes, 2000a). Assuming that a minimal realistic reduction of 3% could be made in feed shrink, with an annual feed cost of \$1100 per cow, the net annual financial impact would be \$16,500 that's recouped for a 500 milking cow dairy. In some cases, shrink reduction has approached 5-8%, which would amount to \$27,500 to \$44,000 for a 500 cow dairy averaged across the same \$1100 per cow annual feed cost figure. The bottom-line is as dairies get larger, there's a large amount of dollars at risk when dealing with feed shrink and inventory control. Keep in mind, these figures strictly represent the income "recouped" that otherwise would have been lost. This gives no additional financial considerations to the merits of having a more consistent nutrition program, which in turn supports better cow health and improved feed efficiency (defined as milk produced per unit of feed intake).

Feed will vary as it's pulled from storage for mixing and feeding, while human mixing errors will also occur. Both are sources of variation in the actual rations delivered and consumed by cows. In turn, ration variation places production, cow health and feed efficiency at risk. Cameron et al. (1998) implicated that feed bunk management is a risk factor for left-displaced abomasums (LDA) through the variations associated with day-to-day feeding and bunk management, and thus the actual nutrients consumed by the cows.

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Contact at: 7905 Black River Rd., Verona, WI 53593, (608) 833-1552, FAX (608) 833-1035, Email: james.a.barmore@monsanto.com

An excellent discussion of how feeding and bunk management can impact cow health, and specifically LDA's, was recently presented (Shaver, 2001).

Broadly defined, shrink is simply dollars spent by the dairy, typically operating expenses, that are not used to generate revenue. There are several areas of significant shrink that occur on a dairy, including excessive cull rates, feed shrink, and labor turnover (Hoekema, 2000). I want to focus on monitoring and managing the variability and shrink that occurs with feeds and feeding, specifically looking at the large financial opportunities gained by establishing better process controls as part of the daily feeding and bunk management.

The success of any team or dairy depends on its ability to consistently execute the basic fundamentals, or as some say the "blocking & tackling". For the dairy, the financial fundamentals of success are maximizing revenues and controlling costs within the parameters defined for the given level of output or production. Financially speaking, a large order of magnitude is better management of feed shrink and associated expenses. One might consider this "blocking and tackling" of feeding. It's important to note that controlling costs within defined production parameters, while minimizing wide variations in expenses, does not necessarily equate to "cutting costs" (Fetrow, 2001). Many dairies forego very significant profit opportunities in the false pursuit of cost-cutting and reducing inputs. By focusing largely on the costs of inputs, rather than the inputs' marginal impact on revenue (typically more milk or better herd health), many dairies place a ceiling on profits. Better management of the feeding should not be simply positioned as a cost-cutting strategy versus opportunities associated with better nutrition.

### **Managing Risk**

One of the first steps to maximizing revenue involves identifying areas of risk and developing appropriate management plans to limit unexpected expenses, controlling the income stream, and reducing the exposure and impact of animal health or catastrophic events that may occur on a dairy. An example of this would be having a management plan in place to maximize forage quality to enhance milk production, while minimizing any animal health challenges caused by lower quality forage. Better quality forage also reduces feed "losses" caused by spoiled feed and excessive fermentation losses.

Suffice it to say, things don't always turn out as planned. To some degree, every dairy tries to minimize risks and variability as part of day-to-day management, but breakdowns are common and opportunities abound in the area of feeding, inventory, and shrink. There are different types and levels of risks that occur on a dairy, which can be managed in three fundamental ways (Fetrow, 2001):

1. Reducing the chance of an undesirable event or outcome (e.g. monitoring systems for early signs of breakdowns or losses)
2. Reducing the impact of an event if and when it does occur (e.g. having treatment protocols in place for health challenges caused by breakdowns)
3. Transferring risk to others (e.g. contracting for a blend of proteins and minerals)

### **Reduce Variation, Improve Consistency**

Variability, or *lack of consistency*, is a dimension of risk and involves feeding management on dairies (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; even the same cow varies 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 planning of future outcomes more difficult. For example, not knowing the packing density and moisture of silage makes planning for the actual tonnage of available fermented silage difficult. Another example would be not having any mixing or feed intake records making the monitoring of the impact of nutrition on cow health and production very difficult. In both cases, variation or deviation from the target points or goals impacts the outcome. Without records, or a monitoring system, the variation cannot practically be measured or managed. In this case, the old adage “if you can’t measure it, you can’t manage it” is quite true.

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 under “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 and management can significantly improve cow performance by improving rumen function and digestion.

Variation makes it more difficult to monitor the effects of any management intervention or action (e.g. producer decides to feed sodium bicarbonate), since the actual effects of the action may be obscured by normal variation. To verify this point, consider how much the daily bulk tank will vary due to every day influences such as weather. If the hypothetical dairy that added bicarb has wide daily swings in milk production due to variable forage quality, inconsistent mixing practices, and variable forage moisture

content, then it will be difficult or impossible to tell if adding the bicarb to the ration actually improves production or health. The effect of bicarb might be positive and cost-effective, but hidden under the daily swings and accepted variation. Management in this case is significantly limited in being able to make accurate and solid business decisions due to the high level of variation (Fetrow, 2001).

The best-managed and typically most profitable dairies seek ways to reduce variation in daily processes. Dairies that can create consistency through protocols and routines will improve their ability to plan and improve management. While breakdowns will still occur, these dairies will be quicker to modify systems and make needed adjustments. In the long-term, dairies that are able to minimize variation, and create better day-to-day consistency within the feeding program will likely be more successful. The answer to getting started with improving variation in the feeding, lies in better monitoring systems. **Day-to-day consistency is a key driver of profitability on well-run dairies!**

### **Monitoring and Control Points**

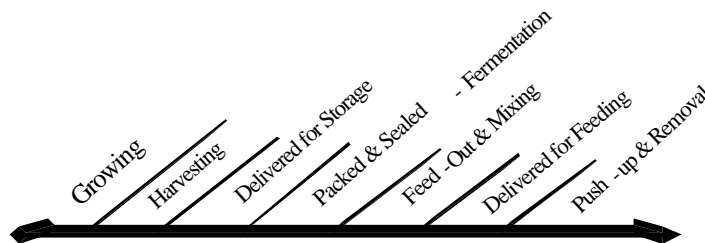
Often, less than expected milk production, or health issues, arise not from a mis-balanced ration “on-paper”, but rather from variation in the quality of feed used for mixing the ration. Although the formulated ration is well balanced, the ration actually consumed by the cows might be something quite different. Even when feed quality has minimal variation, the ration actually consumed can still vary considerably if feed sorting or other bunk management challenges occur. Monitoring the bunk for sorting and other feeding management concerns is extremely important; however, is outside the scope of this paper to fully address. Recent papers by Shaver (2001), Bethard and Stokes (1999), and Barmore (2000) have excellent discussions on monitoring feeding and bunk management. The remainder of this paper will focus on ways to monitor and manage feed inventory, mixing, and shrink to minimize day-to-day variation, while enhancing bottom-line profitability.

Most dairies are challenged to quantify the financial impact of feed related shrink on profits. Simplistically, we all know feed shrink is occurring. Just look at any bunker silo, commodity bay, or round bales of hay being stored...shrink does occur! A more challenging question might be at what control points should management make interventions, and how many resources should be allocated to improve the current level of feed shrink and mixing errors that are occurring? It's tough to know whether to make management interventions unless one knows what is actually occurring. Developing a management plan for the feeding program that includes monitoring and tracking of feed shrink, mixing and inventory has proven to have large paybacks on several dairies. While some feed shrink and mixing errors are inevitable, monitoring and control are critical given the significant amount of “lost” dollars associated with feed disappearance and inaccurate rations being consumed caused by mixing errors.

One of the first steps in developing an effective monitoring system is to identify the most important control points to monitor. So the question might be asked...”what areas of feeding management contribute the largest degree of feed variation and lost dollars?”. To begin to answer this, one might use the “Feed Management Continuum” time-line in figure 2 indicating the many areas where feed shrink and variation occurs.

**Figure 2.**

## Forage Management Continuum



### Focus on Forages

Without question, one of the greatest areas of feed quality variation and shrink is with forages. Variation and shrink in forages occurs by two modes: 1) forage loss as it moves through different handling and storage processes, and 2) microbial deterioration and fermentation dry matter losses. The obscurity of microbial deterioration has led many to believe they have relatively modest forage losses and quality issues. In fact, dry matter losses of 5-20% may be occurring before one actually sees visual evidence of molds on forage (Holmes and Muck 2000a). Actual forage losses and shrink are highly dependent on harvest and storage structures. Data adapted from Holmes and Muck (2000a) indicates total forage dry matter losses can range from about 10% to 50%, including the losses associated with filling, seepage, fermentation gasses, surface spoilage, and feed-out losses.

Holmes and Muck (1999) clearly showed there was a large variation in bunker silo compaction density for both hay crop and corn silages, which would contribute significantly to variation in dry matter losses from dairy to dairy (table 1). Additional information on managing tower silos and putting up quality forage can be found by Holmes and Muck (2000b) and Kung (2001). A website with excellent references on managing forage quality and minimizing forage shrink is [www.uwex.edu/ces/crops/teamforage](http://www.uwex.edu/ces/crops/teamforage).

**Table 1.**

<b>Characteristic</b>	<b>Hay crop Silage (87 silos)</b>			<b>Corn Silage (81 silos)</b>		
	<b>Average</b>	<b>Range</b>	<b>SD*</b>	<b>Average</b>	<b>Range</b>	<b>SD*</b>
Dry matter, %	42	24-67	9.50	34	25-46	4.80
Wet density, lbs/ft <sup>3</sup>	37	13-61	10.90	43	23-60	8.30
Dry density, lbs/ft <sup>3</sup>	14.8	6.6-27.1	3.80	14.5	7.8-23.6	2.90
Avg. particle size, in.	0.46	0.27-1.23	0.15	0.43	0.28-0.68	0.08

\* SD = standard deviation.

### **Minimizing Feed Shrink**

You are never going to eliminate feed shrink completely. The focus should be on controlling it rather than eliminating it. Most dairies can live with average shrink values ranging from 2 to 5 percent. However, shrink often reaches double digits where opportunities to recoup large investments exists.

***Feed shrink can be defined as the loss of feed that occurs from the point of harvest or purchase to what is actually consumed by the animal.***

Again, the question is not whether a dairy has shrink, but rather the extent and value of the shrink. Controlling and reducing shrink typically does not require a large capital expenditure, and the dollars returned go directly to the bottom-line of the financial statement. Remember, reducing feed shrink is about recouping dollars and money already spent and invested in feed. These are feed dollars spent on a dairy that may never have the opportunity to generate revenue, unless recouped and fed to the cows or youngstock.

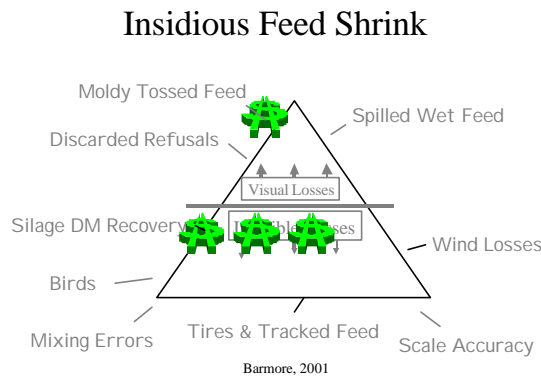
There are several reasons to develop and implement a feed shrink management plan, including:

1. The investment in the feed has already been made.
2. There's a sizeable investment at stake.
3. It's relatively easy to make incremental improvements.
4. Allows better inventory control, feed forecasting, purchasing and contracting.
5. More consistent and productive rations are fed each day.
6. Better tracking of feed intake, an effective daily monitor.
7. Using feed intake records allows opportunity to measure IOFC.
8. Supports better on-farm biosecurity and cleanliness.

## Sources of Feed Shrink

It's already been mentioned there are several major "control points" where feed shrink occurs. This includes harvesting, storage, handling, mixing, feeding, processing, delivery, and any discarded feed. Within each of these areas there are several factors that can contribute to feed shrink, including: wind losses, birds, rodents, tires and tracking feed, seepage and silo run-off, bunk disappearance due to tossing of feed, hot or spoiled feed, moisture loss, mixing errors, and scale inaccuracy. A real challenge is the fact that much of the feed shrink is insidious, and almost invisible during daily activities. Figure 3 illustrates that much of the feed shrink is "sub-clinical" in nature, or invisible to the eye, thus is more difficult to assess.

**Figure 3.**



Here are but a few examples of feed shrink. Some wet byproducts will often have considerable moisture run-off (10-20%) resulting in lost tonnage and value, yet typically the cost or value of the moisture loss is not factored into the actual true cost. The byproducts may in fact still be a wise feeding decision, but the "true" cost of the ingredient should be calculated based on cost plus shrink.

Losses associated with round bales of hay stored outside are another example of largely unaccounted for shrink. Assume there are 1000 pound round bales rolled and made, and in the harvesting process that 20% of the hay was lost. This then requires that 1250 pounds of hay be mowed to make a 1000-pound bale. Another 30% of the hay could easily be lost due to spoilage by letting the bale sit outside uncovered. Later, another 15% of the hay is lost in delivery and feeding. Of the potential 1000 pounds of hay originally rolled into the bale, a total of only 595 pounds of hay remain for conversion into milk or body maintenance. Starting with the original 1250 pounds of hay and ending with 595 pounds of hay consumed, gives a calculated shrink of over 50%. Similar logic and calculations have been applied for storage and covering of bunker silos (Holmes and Muck, 2000a).

Consider shrink when choosing from different feed ingredients, particularly protein, energy, and mineral sources given the larger cost per pound relative to forages. Dry ingredients with small particle size and light bulk density are more susceptible to wind losses. Soy hulls and malt sprouts might be an example of such ingredients. Conversely, wet ingredients that are heavier in bulk density may have higher losses due to feed deterioration and run-off. Estimated losses of various feed ingredients has been reviewed and discussed (Kertz, 1998).

## **Storage Design**

Ingredients are commonly stored on flat-storage (either open or covered) or in upright bins. Placing ingredients in piles outdoors offers the greatest potential for shrink losses, especially if left uncovered. Losses for some ingredients in excess of 20% would not be surprising under these conditions. When evaluating different storage facilities and options, the value of ingredients to be stored must be considered relative to the expected improvements that might be gained with one type of storage over another storage type.

How much might a dairy expect to gain annually by using an upright bin for storing a protein blend with an average annual cost of \$270 versus storing the same protein blend in uncovered flat storage. There are two costs associated with this decision, namely 1) the value of any feed savings through reduced feed shrink in an upright bin, and 2) the opportunity cost of a having cows consume a more consistent and accurate ration each day created by having less variation in mixing errors with auger versus bucket loaded ingredients. The latter, or opportunity cost, is more difficult to specifically measure and evaluate, but must be considered.

If a 500-cow dairy fed an average of 4 pounds of protein blend per cow daily, at an average cost of \$270 per ton, then the annual cost of the protein would be \$98,550. If the shrink of the protein blend could be reduced by 3% by moving from uncovered flat storage to an upright bin, the recouped protein blend value, otherwise lost to shrink, would be \$2,956 per year. In this case, moving to an upright bin would be highly advisable.

**Open-sided commodity sheds** can be managed to keep shrink below 5 percent, but do require proper over-hang and ample concrete apron in front of storage bays to minimize weather exposure and to facilitate loading and handling. Cost and design are key considerations with commodity shed type flat storage. Flat storage can quickly become the most expensive form of storage if over-built or if proper planning does not occur before building. This type of storage tends to be the preferred method of storage for higher inclusion rate ingredients such as whole cottonseed, baled hay, or other ingredients fed at 2-3 pounds or more per head daily. Blends containing higher levels of liquid fat are also often stored on flat storage for ease of handling and flow.

**Upright bins** will do the best job of limiting ingredient shrink, but may also be the most expensive form of ingredient storage. Feed shrink in upright bins can typically be limited to 1-2%. Weighing and mixing tends to be more accurate from bins versus flat storage, which may account for even greater savings over and above actual feed shrink caused by wind loss, tire tracking, birds, etc... Bins are often available through “lease-to-buy” and bin placement programs offered by feed companies and others as incentive and convenience for purchasing preblended ingredients and other feed products.

Disadvantages of upright bins can include: slower feedout rates, feed bridging and down time, ingredient limitations such as high fat levels, and possible equipment failures or damage due to lightning strikes or hitting the bin with other equipment.

So are bins or flat storage superior? Having a combination of both often is the best overall strategy to accommodate both higher inclusion rate ingredients (flat storage) while storing higher cost ingredients with lower feeding rates in upright bins. Shrink will typically be lower in upright bins versus covered or uncovered flat storage. Creating a feed center, with multiple types of ingredient storage and where ingredients are all stored within short distances and easy access of the forages can improve feeding efficiency and mixing accuracy significantly.

### **Utilize Pre-blends**

Whether multiple ingredients are blended together on-farm, or as a service provided by a feed company or local mill, the merits of pre-blending to reduce shrink should be strongly considered. Mixing ingredients together such as proteins, minerals, vitamins, feed additives, and energy sources in a large quantity as a pre-blend improves the chances of getting a more consistent ration while reducing shrink caused by mixing error.

Consider a situation where a ration calls for five different ingredients, other than forages, that are fed individually. If a feeder overfeeds (usually over-fed versus under-fed) each ingredient by an average of 20 pounds per load...just an extra shake of the loader bucket, then by feeding five ingredients separately the feeder would be wasting 100 pounds of feed per load. If six loads of TMR were being fed each day for all milking pens, then a total of 600 pounds of extra feed would be mixed daily. With an assumed average value of \$0.065 per pound for all five ingredients, this would amount to \$1170 per month of “feed shrink”.

Compare this to using a pre-blend of the five ingredients, where instead of adding five different ingredients to all six TMR loads instead only the one pre-blend is mixed. With the same over-feeding rate of 20 pounds for the pre-blend, multiplied by the six TMR

loads daily, the amount of pre-blend over-fed per month figures at 3,600 pounds versus 18,000 pounds for the five separate ingredients. Assuming a mixing or labor charge of about \$15 per ton, the pre-blend average cost becomes \$0.0725 per pound, or a total of \$261 per month compared to the \$1170 charge when the ingredients were fed separately. On an annual basis, this would amount to a feed cost savings of \$10,908 using the pre-blend versus individual ingredients. Although, variation in mixing errors would be expected from dairy to dairy, experience has shown that mixing errors (over-fed) less than 20 pounds per ingredient would be the exception rather than the rule. It's only natural that low inclusion rate ingredients are more susceptible to mixing errors, as are ingredients that tend to be sticky or are more difficult to handle. Group size and frequency of mixing factor into the potential dollar savings based on actual feeder error.

Pre-blends also will minimize the amount of over-mixing and potential forage particle size reduction that could occur. Shaver (2001) and Bethard and Stokes (1999) do a nice job of discussing mixing errors and effective fiber evaluation.

**Other advantages of utilizing a pre-blend can include:**

- ✓ reduces carrying cost of ingredient inventory
- ✓ improves ingredient quality control
- ✓ just-in-time inventory, potentially fresher feed available
- ✓ risk exposure reduced and shared with third party
- ✓ minimal cost differences for blending
- ✓ additional services possibly provided in conjunction with pre-blend
- ✓ labor savings and more cost-effective deployment of on-farm labor

Other steps to considered for reducing and managing feed shrink, include:

- ✓ avoid feeding in an elevated “H-bunk” that encourages feed throwing
- ✓ periodically check scale load cells for accuracy
- ✓ utilize batch mixing charts with conversions made for moisture variations
- ✓ establish mixing protocol and sequencing based on specific ingredients
- ✓ control rodents and wild animals in and around plastic storage bags
- ✓ weigh all deliveries of purchased feeds
- ✓ closely manage forage feedout to maximize aerobic stability of the TMR in the bunk, in turn minimizing the feed refusals created by out-of-condition feed due to heating or secondary fermentation
- ✓ record receiving dates and tonnage on all in-coming ingredients

**Monitoring and Tracking**

The scope and financial benefits of implementing a feed inventory and shrink management plan have been discussed. 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 to high producing and special needs cows. The key to improving 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 determine specific causes to allow implementation of a better management plan.

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 is always a key to improving, and must be considered a key to building a better feeding management plan to address reducing risk exposure.

There are several methods to monitoring and tracking feeding. No one system will fit all dairies, nor are any systems 100% accurate. Essentially, there are three ways to approach setting up a monitoring system, including: 1) using a simple "pencil & paper" system of recording, 2) using spreadsheets, or 3) using a computerized software program specifically developed for tracking and monitoring feeding and inventories. 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.

**A simple method** of monitoring feeding involves recording daily amounts of ration offered and refused, and then comparing this to inventories taken on a regular basis. This requires that a feed intake log be kept for each pen or group of cows, while all feed purchases are recorded for actual scaled amounts, and when they were delivered. Often the amount of ration fed and refused is a more accurate figure to monitor with this system, versus actual feed disappearance, because of the challenges of knowing what are actual ingredient inventories. A distinction to keep in mind is that bunk disappearance of feed is not necessarily the same as feed intake. Depending on how much feed is tossed into the alleys during feeding, and how accurate feed refusals are recorded, will determine the difference between feed disappearance and true dry matter intake. More feed tossing may occur with post-n-rail bunk designs when compared to a self-locks due to freedom of head movement for the cow.

Another method of monitoring feeding and inventory is to **use a spreadsheet**, where actual weights of the ration offered daily can be recorded by pen or group along with the

feed refusals. These amounts can be automatically subtracted from the running inventories if available in the spreadsheet. Advantages of using the spreadsheet system include the ability to store and record historical data, while also being able to graph current information by pens. The cost of using a spreadsheet system is very favorable, but does require that employees be very well-trained. Since all data is captured through human input, the same data is subject to human errors which can be a limiting factor when compared to using more automated computerized scale interfaced systems such as EZfeed, FeedWatch, Feed Supervisor, or TMR Tracker.

**Computerized software scale interfaced programs** are rapidly becoming of interest due to their ability to automatically capture feeding and mixing information without requiring the feeder to hand-enter data. These systems generally include a scale interface mounted on the feed truck or TMR mixer, software, and a hand-held computer or radio frequency transmitter that sends data to a desk or palm computer. These computerized feeding management systems are becoming easier to use and manage as they are further developed and improved with input from dairies and nutritionists alike. Future applications will likely include other data collection such as weather that can be aligned with feeding data to help better understand how the environment impacts variation in performance.

These programs record automatically the actual amounts loaded and fed relative to projected, capturing any deviations and errors for each ingredient and pen. Time of delivery and mixing times can also be monitored by day of week or feeder. Computerized feeding systems can perform inventory tracking based on what is actually loaded and unloaded. This in turn can be used for feed forecasting and purchasing. Tracking of feed intake and feed refusals by pen, when interfaced with milk production data can become a very powerful management tool for looking at Income Over Feed Costs (IOFC) across different feeding and management strategies employed.

The ability to more accurately monitor, evaluate, and improve upon the amount of variation that is occurring in a feeding program is one of the greatest benefits of these computerized systems. It's very important to remember that the best-balanced ration is only a theoretically delivered ration, given that actual mixing and ingredient specifics are usually unknown. These programs allow a dairy to move beyond projected and planned to an "actual" method of managing the feeding and nutrition. Examples of tables and screens from some of the software programs are shown at the end of this paper in the appendix.

## **Implementation & Summary**

Feed costs represent the single largest variable expense of producing milk. Many dairies have the ability to monitor and track feed inventories and feed use, but lack a well

thought out system and plan. The economic incentives for creating such a plan are large. Often, when data is available it's under-utilized. Collecting feed disappearance and feed inventory information allows dairy managers 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.

Begin by making a commitment to reducing feed shrink and managing the feeding process on a daily basis; speak to this commitment with employees and other professionals supporting the dairy. Understand the control points, and where the greatest economic returns typically occur with improvements. Make feed inventory and shrink management part of the feeder 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 storage facilities and bins along with computer 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 feed shrink and ration variation.

Now get busy, and celebrate the success and improvements along the way!

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Software programs mentioned in this paper by name is only done for identification purposes, and in no way is meant as an endorsement of one product over another.

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# **Economic Consequences of Extending the Calving Intervals of Multiparous Dairy Cows**

**Bruce L. Jones**

**Professor of Agricultural & Applied Economics, University of Wisconsin - Madison and  
Extension Farm Management Specialist, UW Center For Dairy Profitability**

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Numerous studies have been conducted through the years that have concluded that dairy producers can lose potential profits as calving intervals are extended (3, 5, 6, 7, 9). As such, it has generally been accepted that dairy producers should be attempting to manage for 12 to 13.5 month calving intervals.

In recent years recommendations for extending calving intervals have appeared in the popular press (8). The logic underlying this recommendation is that there is less need to initiate another lactation in a cow if she is producing at relatively high levels in the latter days of her lactation.

This paper reports the result of a study that was performed to evaluate the merits of this recommendation for extending the calving intervals of cows treated. We first consider the economics of the milk production process and then discuss a methodology for evaluation the economic consequences of extending calving intervals in dairy operations. Finally, results of various analyses are reported that address various questions of how calving intervals affect profits in dairy.

### **Milk Production as an Economic Process**

The lactation of a dairy cow can best be described as a repetitive process that begins with the birth of a calf and ends with a 55 to 60 day period when a cow is “dried-up” and allowed to get into condition to give birth to another calf. Between the time of the calving and the dry period, the dairy cow is milked. Over this period a cow’s milk production varies. Initially milk production increases each week until it peaks sometime around the sixth to ninth week of lactation and then it declines in subsequent weeks (4).

The length of the dairy production process just described depends on the calving interval; which is the amount of time that passes from the birth of one calf to the next. Calving intervals of 13 to 14 months are common for commercial dairy operations but longer calving intervals occur when producers are unable to get cows impregnated in a timely manner.

The early weeks of a cow’s lactation are more profitable than the later ones because a cow gives more milk early in her lactation (2). This is an important point because it suggests a producer can maximize profits over time by making sure a cow is at peak production as frequently as possible. This is done by keeping the calving interval to a minimum, because a cow gets back to peak production sooner if she is calving every 13 months versus every 16 months.

### **Evaluating Investments Over Time**

Purchasing a dairy cow that will yield returns over three or more years is an investment decision that is comparable to purchasing stocks, bonds, or real estate. In all of these cases, one commits capital to an investment that will in turn yield returns in the future. The primary goal in making any of these investment decisions is earn maximum profits. Since the purchase of a cow is the

same as any other investment activity, it follows that the techniques used to evaluate the profitability of investments like stocks and bonds can be applied to decisions dairy cattle investments. In this section we will consider some of the concepts of investment analysis that will be the basis of this study.

The profitability of an investment is partially determined by the level of the returns yielded by the investments but it is also determined by the timing of the returns. Time has an effect on investment profitability because a cost is incurred any time there is a delay in receiving a return on an investment. Economists refer to this cost as the opportunity cost of capital.

The opportunity cost of capital is essentially the interest earnings one forgoes on returns received in the future versus immediately. This cost is incurred on all investments and varies depending on how much time passes before returns are gained from an investment. Those investments that yield returns over a short period of time have low opportunity costs while investments with longer payout period have higher opportunity costs for capital.

Discounting is a methodology that is used to account for the opportunity cost one incurs when undertaking an investment. With discounting one computes the present values of all cash flows that will be received from an investment over time. By making this valuation adjustment, one accounts for the potential interest earnings one forgoes when returns are received over time versus immediately.

The concept of discounting is illustrated in the example presented in Table 1. For this case it is assumed an investment, costing \$60, yields an annual return of \$20 per year for four years when the opportunity of capital is 8%. The returns for the investment are reported in the second column of the table and the discount factors that apply to these returns are reported in the third column. The values in the right hand column are the present values that are computed by multiplying the cash flows by the corresponding discount factors. The net present value presented at the bottom of the table was obtained by summing the reported present values.

The present values reported in the above table show that the value of a \$20 return diminishes over time. This is evidenced by the fact that the present value of the \$20 received in year 1 is \$18.518 while the value of the \$20 received in year 4 is only \$14.70. This inverse relationship between value and time, which is reflected by the discount rates presented in the table, is the reason why it is one's preference is to receive returns from an investment sooner versus later.

The analysis laid out in Table 1 is an example of a capital budgeting technique known as net present values analysis. Under this analysis technique an investment is judged to be acceptable whenever the net present value is positive. This methodology is the most accurate procedure for evaluating investments because it accounts for the opportunity costs one incurs on capital.

In some cases one may be faced with the problem of choosing between two recurring investment alternatives with different lives. For example, one investment option may yield returns over four years while another yields returns over five years. These differences in the lives of the

investments have to be taken in to account as well when choosing between investments. One way of doing this is computing what is called the annuity equivalent approach (1).

The annuity equivalent, which reflects the periodic return one could receive over the life of the investment for each dollar that is presently on hand, is computed in two steps. First the net present value of an investment is computed just as was done in the previous example. Next, the net present value is multiplied by an annuity factor which corresponds to the life of the investment. The procedure for computing annuity equivalents for investments is illustrated in the example detailed in Table 2.

For this example, one has the option of choosing Investment A (INV A) or B (INV B) which yield the cash returns detailed in Table 2. INV A has a four-year life and the life of INV B is five years. Both of these investment cost \$60.00 (the -60.00 reported for year 0) and yield annual returns of \$20 per year in years 1 through 4. The only difference between these two investments is that INV B yields an additional \$1.50 of return in year 5.

The net present values reported for Investments A and B are 6.24 and 7.621, respectively. Given these net present values one might conclude that INV B is the preferred investment because it results in the higher total return. However the annuity equivalents for the two investments show that INV A is the preferred investment because it yields an annual return of 1.999 per year while INV B only yields an annual return of \$1.819.

The lower annual return for INV B is explained by the fact that this investment takes five years to yield returns worth \$7.621 while INV A only takes four years to generate returns valued at \$6.24. Because INV A has a shorter life than INV B, it is possible to repeat this investment more frequently than INV B. This quicker turnaround for INV A is the reason it yields a higher annual return.

The example laid out in Table 2 is representative of the analysis that must be performed when one is trying to decide whether a 13 month calving interval for a dairy cow is more profitable than say an 18 month calving interval. Since this decision about calving intervals involves differences in the timing of returns, it follows that annuity equivalents should be computed to compare the profitability of these calving options.

### **Net Present Value Analysis of Various Calving Interval Strategies**

The net present value and annuity equivalent analysis techniques just discussed were used to evaluate seven different calving interval strategies that could be employed by a dairy producer. The strategies evaluated, which were defined in terms of the number of days (d) between calvings, are as follow: 360 d , 390 d, 420 d, 450 d, 480 d, 510 d , and 540 d.

The analyses were performed under the assumption that a multiparous cow would be held for a total of three complete lactations. The daily return and cost data shown in Figure 1, and the other return and cost data presented in Table 3 were used in estimating the daily returns and costs that

were expected to be earned over the span of the cow's productive life. The milk returns shown in Figure 1 reflect a base selling price of milk of \$13 per hundredweight and total milk production of 24,282 pounds of milk in the first 305 of a lactation. The feed costs were estimated under the assumption corn cost 2.50 per bushel, hay cost \$125 per ton and soybean cost of \$180 per ton. The labor costs were computed assuming \$9.00 per hour was paid for labor and the annual opportunity cost of capital was set at 8 percent.

The milk return estimates presented in Figure 1 reflect the returns one would expect to obtain over the first lactation of a multiparous cow. These milk returns were adjusted downward for the second and third lactations, to reflect the fact that average milk production declines and somatic cell count increases as cows age. The adjustment for somatic cell count was made to account for the loss of quality premiums as cell counts rise. These adjustments in milk production and somatic cell counts were patterned after the trends exhibited by DHI test herds. These trends in the changes average milk production and somatic cell counts over time, for cows 36 months old or older, are presented in Figures 2 and 3, respectively. (See Appendix 1 for the adjustments that were made in milk production and somatic cell count based on the values reported in Figures 2 and 3.)

### ***Base Results***

The net annual returns from milk and calves and the net annual cow ownership costs reported in Table 4 illustrate nicely the trade-offs that occur as calving intervals are extended. The annual cow ownership cost falls, but the value of the annual net returns from milk and calves also declines. Thus, costs savings (reductions in cow ownership costs) are offset by declines in annual returns.

Extending the calving interval reduces the annual ownership costs for a cow because more time is available to cover the cost of replacing a cow (difference between the purchase price of a cow and the slaughter value). This reduction in annual ownership cost is the payoff from extending the calving interval of a cow.

While extending the calving interval reduces cow ownership costs, it also reduces the annual value of net returns from milk and calves. This decline in the value of annual net milk and calf returns occurs because with extended calving intervals more time elapses before a cow is back producing at peak levels of production in the early stages of her lactation. Thus a cow spends less time producing at her peak capacity. This is why the value of annual net milk returns is less when calving intervals are extended to greater number of days.

From the values reported in Table 4 for the seven calving intervals evaluated, we see two important things. First, we see that annual returns decline at an increasing rate as calving intervals are extended beyond 390 days. Second, and more interesting, we see that the 360 days calving interval does not result in the highest annual return.

The lower returns for the 360 day calving interval are evidence that there are some losses

associated with shortening the calving interval to something less than 390 days. These losses are probably related to the reductions in milk production and increases in somatic cell counts that occur as cows move into their second and third lactations. These changes in a cow's milk production over lactations cause the profits to fall as a cow moves into her second and third lactations. Given this, it follows that dairy producers would be inclined to extend calving intervals in order to postpone declines in milk production and increases in somatic cell count. This explains why the returns reported for the 390 day calving interval are greater than those for the 360 day calving interval.

The lower returns reported for calving intervals of 420 days or more, indicate that the financial losses associated with spreading out returns over more time ultimately outweigh the gains associated with keeping cows milking in their first and second lactations longer and spreading out replacement costs over more time. These lower returns for the longer calving intervals represent the financial losses dairy producers incur from milking cows more days versus getting cows back to their peak days of milk production more quickly.

### ***Impacts of Changes in Milk Price, Total Milk Production, Cost of Capital***

The results reported in Table 4 apply to a specific set of assumptions about a variety of variables. It was recognized that different results could be obtained if some factors such as milk price or milk production are different. To explore this possibility three other analyses were performed to see if extended calving intervals might be advisable under different economic conditions. For one of these analyses the milk price was changed from \$13.00 to \$14.00 to see if an increase in milk price makes extended calving intervals more desirable. A second analysis was performed to see if an increase milk over 305 days from 24,282 pounds (base assumption) to 25,807 pounds makes extended calving intervals more preferable. A third analysis was performed under the assumption that the opportunity cost of capital was 7 percent versus 8 percent as was assumed for all other cases. This latter analysis was conducted to see if extended calving intervals are more preferable when capital costs are at lower levels. The results of these analyses are summarized in Table 5.

In all three of the analyses described above, returns were at a maximum when the calving interval was 390 days. This information is noteworthy because it is further evidence that is advantageous for a dairy producer to strive for short calving intervals versus extended ones.

### ***Gains From Genetic Improvement and The Length of Calving Intervals***

Another factor that needs to be considered when evaluating the profitability of various calving interval options is the genetic improvement that occurs as genetically superior cows are incorporated into a dairy herd over time. This improvement in the productivity of cows is important to producers because the profitability of their operations will rise over time as higher producing cows enter their herds.

How quickly a dairy producer is able to gain the benefits of genetic improvement in part depends on the length of the calving interval for the producer's herd. In general, a producer's gain from genetic improvement should be greatest when calving interval is held to a minimum because this management strategy allows for higher producing cows to enter the herd sooner.

To see if shorter calving intervals are indeed preferred when the productivity of cows is rising over time due to genetic improvement, another analysis was performed using the model developed for this study. For this analysis, it was assumed that returns over feed costs would grow 1 percent each time a cow was culled and replaced with genetically superior cow. The results of this analysis are reported in Table 5, along with the results that were obtained in the absence of genetic improvement.

The data in Table 5 show two important things. First, as expected, these data show that genetic improvement does result in improved profits for producers. Second, and more importantly, these values show that producers can experience greater gains from genetic improvement when calving intervals are held to a minimum. This point is evidenced by the fact that the gains from genetic improvement reported for the shorter calving intervals are greater than those reported for longer calving intervals. These results are important because they further suggest that shorter calving intervals are preferable to extended ones.

## **Conclusion**

The results of this study that were obtained using net present value capital budgeting techniques consistently show that maximum profits are earned when the calving interval of a dairy cow held at 390 days. This finding is important to dairy producers because it means they will lose profits if they follow the recommendations of some people who are saying extended calving intervals are advisable. Results of this study also clearly show that extended calving intervals are less profitable even with higher milk prices, higher milk production in cows, and lower costs of capital. One other important finding of this study is that extended calving intervals tend to cause producers to lose the gains that come from genetic improvement over time. Given all of these findings, it appears that there are no economic payoffs from extending calving intervals to 420 days or longer.

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Year	Cash Flow (\$)	Discount Factor	Present Value
0	-60	1.0000	-60.0000
1	20	0.9259	18.5185
2	20	0.8573	17.1468
3	20	0.7938	15.8766
4	20	0.7350	14.7006
		Net Present Value	6.2425

Year	Discount Factor	Cash Flow ( \$ )		Present Value	
		INV A	INV B	INV A	INV B
0	1.0000	-60	-60	-60.0000	-60.0000
1	0.9259	20	20	18.5185	18.5185
2	0.8573	20	20	17.1468	17.1468
3	0.7938	20	20	15.8766	15.8766
4	0.7350	20	20	14.7006	14.7006
5	0.6806		1.5		1.0209
		Net Present Value		6.2425	7.2634
		Annuity Factor		0.3019	0.2505
		Annuity Equivalent (Product of net present value and annuity factor )		1.8846	1.8195

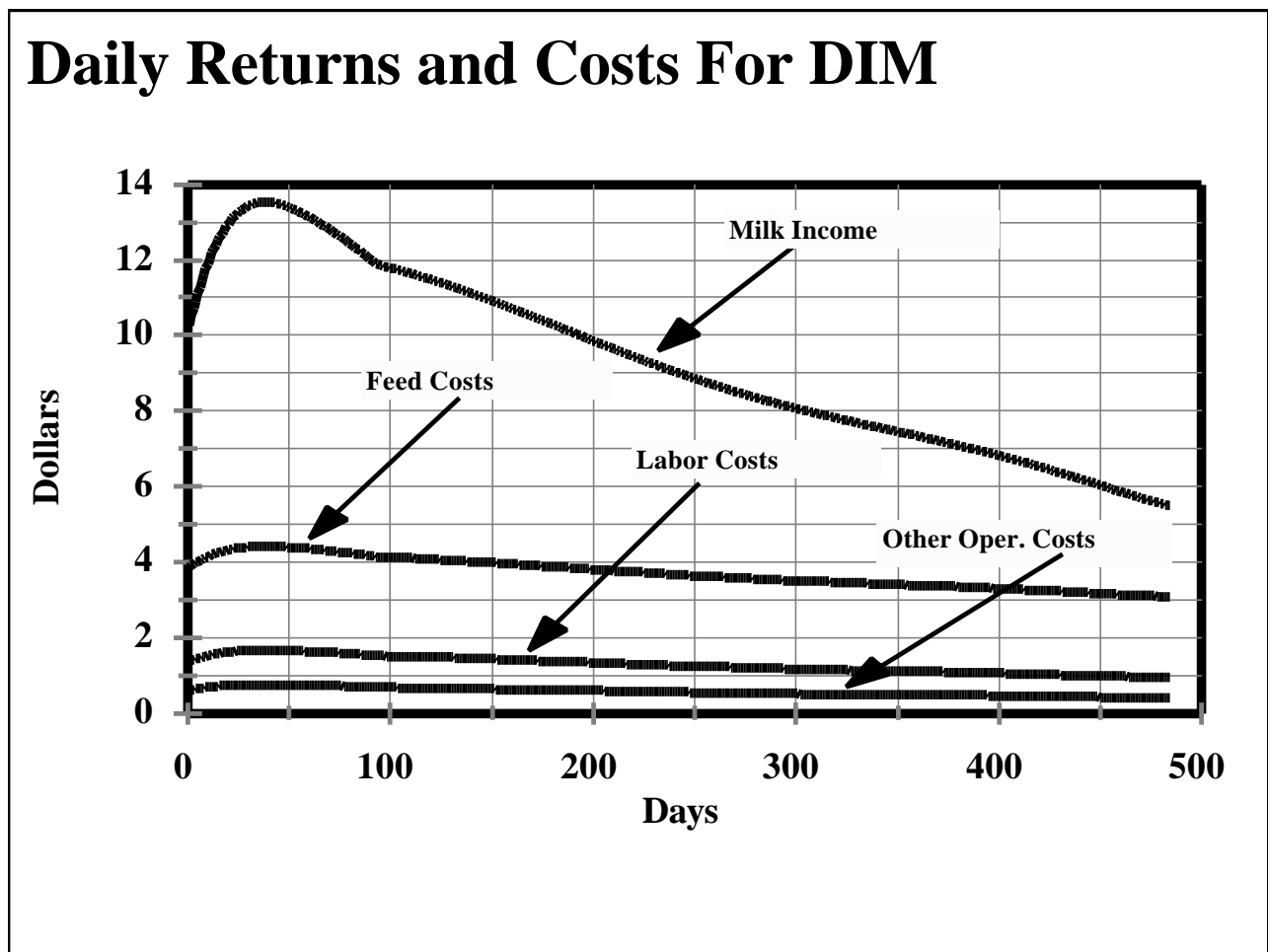
<b>Table 3: Assumptions Used in Computing Daily Returns and Costs of a Dairy Cow</b>	
<b>Milk Production:</b>	
Peak Daily Milk Production	100 lbs
Total Milk Production Over 305 Days	24,282 lbs.
Base Somatic Cell Count (SCC) For First Lactation( In 1000's )	100
<b>Milk Prices:</b>	
Base Milk Price	13.00/cwt
SCC Premium Standard ( In 1000s )	350
Milk Quality Adjustment per 1000 SCC [ SCC - SCC Premium Standard ] Greater Than Zero ( 0 ) – Premium Less Than Zero ( 0 ) – Discount	\$.0015/cwt.
<b>Cow and Calf Values:</b>	
Purchase of Cow (At Day 0)	\$1600/head
Sale of Cull Cow (At End of Third Lactation)	\$400/head
Sale of Calf (At End of Each Lactation)	\$67.50/head
<b>Costs:</b>	
Breeding	
300 Days Prior to End of Calving Interval	\$12.50
270 Days Prior to End of Calving Interval	\$12.50
Health Costs (One Third of Total Cost Incurred on Day 15, 45 and 75 of a Lactation)	\$85.00
Dry Costs ( For a 55 Day Period )	\$2.85/day
<b>Opportunity Cost of Capital – Annual Percentage Rate</b> <i>(Equivalent to Daily Interest Rate of .02109 with Daily Compounding)</i>	8%

Calving Interval in Days	Annual Value of Net Milk Returns and Calves	Annual Ownership Costs on Cow	Net Annual Returns	Difference From Return For 390 Day Calving Interval
-----	-----	-----	-----	-----
360	1211.37	459.95	751.42	-5.91
390	1187.80	430.47	757.33	0.00
420	1161.07	405.20	755.87	-1.46
450	1131.75	389.33	742.42	-14.91
480	1099.62	364.21	735.41	-21.92
510	1064.34	347.35	716.99	-40.34
540	1026.26	332.39	693.87	-63.46

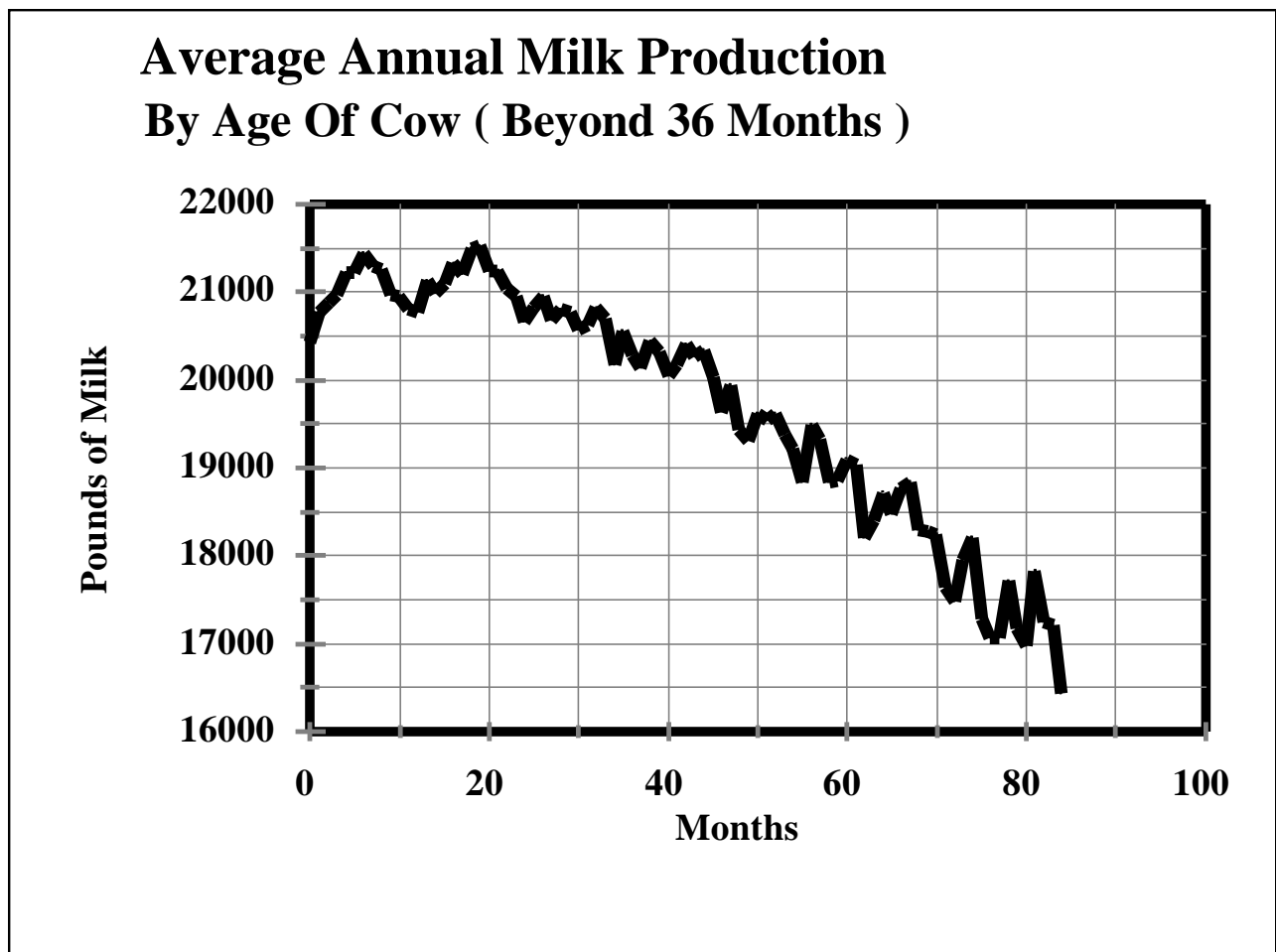
Calving Interval in Days	Returns For Case Where:			Returns For Base Case
	Milk Price is \$14 vs \$13 Per CWT.	Milk Production Over 305 Days is 25,807 lbs vs 24,282 lbs.	The Opportunity Cost of Capital is 7% vs 8%	
-----	-----	-----	-----	-----
360	989.05	908.68	762.40	751.42
390	992.24	916.17	768.20	757.33
420	987.75	915.98	766.58	755.87
450	977.02	909.52	758.94	742.42
480	960.46	897.30	745.70	735.41
510	938.17	879.48	727.01	716.99
540	910.89	856.81	703.58	693.87

<b>Table 6: Net Annual Returns ( In Dollars) Per Dairy Cow Under Various Calving Intervals With and Without Genetic Improvement</b>			
<b>Calving Interval in Days</b>	<b>Annual Returns With 1% Growth In Milk Returns Over Feed Costs Due To Genetic Improvement</b>	<b>Annual Returns With No Growth In Milk Returns Over Feed Costs</b>	<b>Annual Net Gains From Genetic Improvement</b>
-----	-----	-----	-----
360	804.12	751.42	52.70
390	806.94	757.33	49.61
420	802.48	755.87	46.61
450	792.14	742.42	49.72
480	776.34	735.41	40.93
510	755.23	716.99	38.24
540	729.52	693.87	35.65

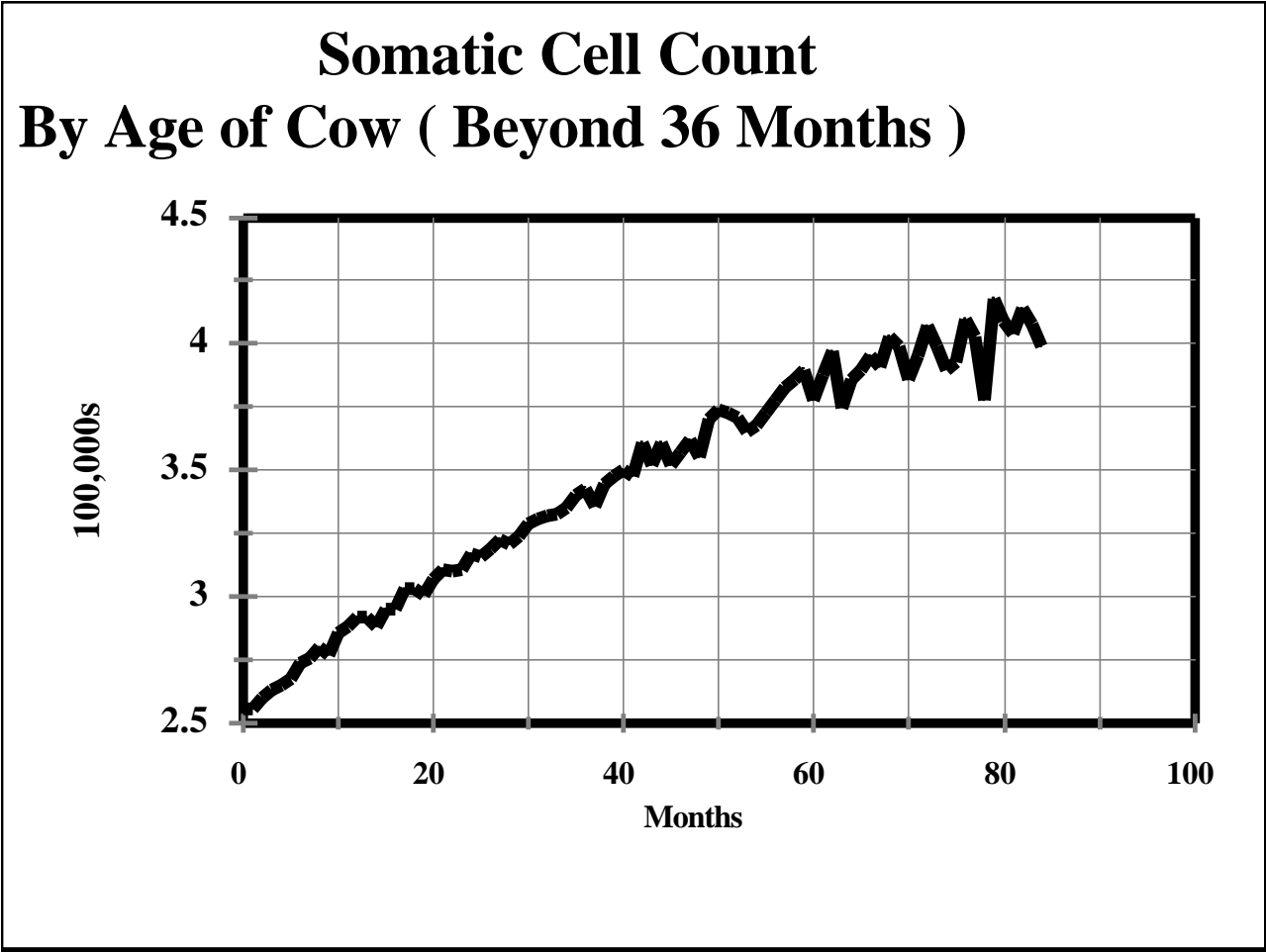
**Figure1: Daily Returns and Cost Used In Estimating The Daily Returns Over The Lactation Of A Cow**



**Figure 2: Average Annual Milk Production For Multiparous Cows  
36 Months Old Or Older**



**Figure 3: Average Somatic Cell Count For Multiparous Cows  
36 Months Old Or Older**



**Appendix 1 : Adjustments Made in Milk Production and Milk Price Over Lactations Based on the Trends Observed In DHI Test Dairy Herds ( Figures 1 and 2 )**

	Lactation	Calving Interval in Days						
		360	390	420	450	480	510	540
<b>Adjustments in Annual Milk Production</b>								
	<b>1</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>
	<b>2</b>	<b>0.9988</b>	<b>0.9983</b>	<b>0.9977</b>	<b>0.9970</b>	<b>0.9963</b>	<b>0.9955</b>	<b>0.9946</b>
	<b>3</b>	<b>0.9881</b>	<b>0.9854</b>	<b>0.9824</b>	<b>0.9791</b>	<b>0.9756</b>	<b>0.9718</b>	<b>0.9678</b>
	<b>4</b>	<b>0.9678</b>	<b>0.9612</b>	<b>0.9541</b>	<b>0.9463</b>	<b>0.9379</b>	<b>0.9290</b>	<b>0.9194</b>
	<b>5</b>	<b>0.9379</b>	<b>0.9259</b>	<b>0.9127</b>	<b>0.8985</b>	<b>0.8833</b>	<b>0.8670</b>	<b>0.8496</b>
<b>Adjustments in Annual Milk Price</b>								
	<b>1</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>
	<b>2</b>	<b>0.9986</b>	<b>0.9985</b>	<b>0.9984</b>	<b>0.9983</b>	<b>0.9982</b>	<b>0.9980</b>	<b>0.9979</b>
	<b>3</b>	<b>0.9972</b>	<b>0.9970</b>	<b>0.9968</b>	<b>0.9966</b>	<b>0.9963</b>	<b>0.9961</b>	<b>0.9959</b>
	<b>4</b>	<b>0.9959</b>	<b>0.9955</b>	<b>0.9952</b>	<b>0.9948</b>	<b>0.9945</b>	<b>0.9941</b>	<b>0.9938</b>
	<b>5</b>	<b>0.9945</b>	<b>0.9940</b>	<b>0.9936</b>	<b>0.9931</b>	<b>0.9926</b>	<b>0.9922</b>	<b>0.9917</b>

# **Cow Longevity and Optimal Culling Decisions In Dairy Operations**

**Bruce L. Jones**

**Professor, UW-Madison Department of Agricultural and Applied Economics and  
Extension Farm Management Specialist, UW Center for Dairy Profitability**

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One of the problems confronting dairy herd managers is deciding how long they should keep a cow in a dairy herd before replacing her with a heifer. This culling decision is important because profits can be lost if cows are either held for too short or too long a period. In the former case, profits are lost because annual replacement costs (the difference between the purchase price of a cow and the slaughter value of a cow) are spread too few years. In the latter case, profits are lost because the annual returns from holding a cow longer are not as great as those that could be obtained from a replacement animal.

In this paper we will consider this replacement decision problem. We will consider some data which show how a dairy cow's performance changes over time and then discuss the results of analyses which show how culling rates and cow holding periods will vary depending on such factors as the replacement price of cows and the price of milk. Results are also presented which show how a dairy producer's profits may change depending on the rate at which cows are culled from a herd.

### **Returns and Costs of a Dairy Cow Across Lactations**

The values in Table 1 are assumed to be representative of the income and expenses one would experience, over time, on a dairy cow milked over a series of lactations. These income and expense data are drawn from existing budget data for Wisconsin dairy herds and DHI production indices. These indices, which are presented in Figure 1 and derived from DHI data, reflect the changes that occur in a dairy cow's total annual milk production, somatic cell counts in milk, and culling rates for dairy cows over time.

As shown in Figure 1, milk production declines as cows age while somatic cell counts and culling rates increase as cows get older. These changes in these three factors either depress income or increase costs over the life of a cow. Declines in milk production obviously result in lower income levels; and increases in somatic cell counts also depress income. High somatic cell counts lower the pay price for milk because less quality premiums are paid for milk cell counts are relatively high. The net result of this price adjustment is a decline in income. Culling generally results in higher expenses because veterinary fees and other health related costs tend to go up as cows are culled from dairy herds.

The income and expense data in Table 1 show that net returns earned on a dairy cow decline as a cow is milked for more and more lactations. This down-trend in net returns is important because it means a dairy producer has an economic incentive to cull cows after a few lactations because holding a cow longer depresses net returns.

Culling cows after say 3 or 4 lactations will keep net returns up, but it also results in higher replacement costs for a dairy producer. This increase in replacement cost occurs because culling a cow sooner leaves less time for a dairy producer to recover the cost of a replacement cow or heifer. This shorter holding period for a cow drives the annual cost up just as depreciating a

tractor over 5 years versus 10 years causes ownership to incur greater annual depreciation expenses.

## **The Culling Decision**

Since both annual net returns and annual cow ownership costs are affected by the length of time cows are held in a herd, it is not easy to determine how long one should be willing to keep cows in a dairy herd. In order to make this determination, one has to simultaneously compare the cost savings from holding a cow longer (lower annual replacement costs) with the returns that are lost as cows are milked for more lactations. If the cost savings from lower ownership costs are greater than the value of the lost milk returns, it follows that one should extend the holding period of cows. Alternatively the holding period of cows should not be lengthened if the cost savings on ownership costs are less than the reductions in milk returns.

The decision process just described can be simulated using linear programming techniques. With this methodology, one constructs a mathematical model containing the return and cost data, like those presented in Table 1, and other specifications, such as the replacement cost and slaughter value of cull cows, and then uses the model to solve for the dairy cow holding period that results in maximum net returns or profits. This optimization technique is very powerful and useful because it allows one to consider actions and identify that action which best achieves a management objective. For this particular study the management objective is profit maximization.

## **Results of the Analysis**

The values in Table 2 reflect profit maximization management strategies defined in terms of culling rates and maximum holding periods for cows in terms of lactations. These results are for a dairy herd where cows produce 20,370 pounds of milk in their second lactation when milk prices are \$10, \$12, or \$14 and the per head replacement heifer prices are \$1200, \$1500, or \$1800.

The Table 2 values, labeled % Heifers, reflect the percent of a herd culled per lactation period. These values are negatively related to the per head replacement cost, such that the percent of heifers in the herd is lower for the higher replacement animal values. This is expected since it is more costly to cull dairy cows when one is paying \$1800 versus \$1200 per replacement animal.

The values labeled, Maximum Lactations Achieved, reflect the length of time a producer is willing to keep cows in a herd. These values vary inversely with the culling rates. In general, the maximum number of lactations for a cow ranges between 6 and 7. The shorter holding periods are observed when replacement costs are \$1200 per head but in the case where the milk price is \$15, the holding period is also 6 lactations when a replacement animal costs \$1500.

It is important to note that only 6 to 9 percent of cows in the herd actually achieve the maximum number of desired lactations. These low percentages reflect the fact that the number of cows available to go to the next lactation steadily decreases, as cows develop health and reproduction problems.

One of the interesting things shown by the Table 2 values is that holding periods are longest when the replacement purchase price is \$1800 per head. These results are as expected given that one would want to avoid culling when replacement animals are relatively expensive.

The values in Table 2 also suggest that milk price has an effect on the holding period of cows. Notice that in those cases where replacement heifers cost \$1500 or \$1800 per head, the holding periods are longest when milk is \$10 per hundredweight. This finding is not surprising, given that the economic incentive for avoiding culling costs would be greater when the price of milk is relatively low.

The values reported in Table 3 summarize the results for cases where total milk production is either 26,014 pounds or 22,664 pounds for situations where milk prices range from \$11 to \$15 and the per head replacement cost for a cow was \$1800. These different milk production levels are considered to see if the length of the holding period should be change depending on the productivity of a dairy herd.

In general, the Table 3 values suggest that culling rates and maximum number of lactations for cows are the same for the two levels of milk production considered. The only exception is for the situation where the milk price is \$11. For this particular situation, the culling rate for the herd producing at 22,664 pounds of milk drops to 21.95 percent and the maximum number of lactations increases from 7 to 8. This lengthening of the holding period under low milk prices suggests that it is more profitable to hold lower producing cows longer in situations where milk prices are relatively low.

The values in Table 4 are perhaps the most interesting and important in that they show that culling cows at rates close to the current industry norm of 33 percent versus optimal rates can result in economic losses for dairy producers. For this case, the price of milk is \$13.00 per hundredweight and the milk production of a cow for second lactation is 26,014 pounds. The culling rate of 33 percent results in cows being held for a maximum of four lactations with 13.7 percent of the herd being held for this amount of time. This culling strategy is considerably different from the optimal strategies selected by the linear programming model developed for this study. The optimal culling strategies call for roughly 23 to 25 percent of a herd to be culled annually with cows held for up to 6 to 7 lactations.

The differences in the net returns for the 33 percent culling rates and those for the optimal culling strategies are -\$50.74, -\$74.74, and -\$102.78, respectively, for replacement costs of \$1200, \$1500, and \$1800 per cow. The lower returns for the 33 percent culling rates are

evidence that dairy producers incur considerable economic losses when they elect to cull cows rather frequently.

The higher net returns reported for the optimal culling rates of 23 to 25 percent reflect the income gains dairy producers can capture if they reduce culling rates and hold portions of their herds for 6 to 7 lactations. By achieving these management goals, farmers with 400 to 500 cows can boost their total profits by as much as \$40,000 to \$50,000 per year. This is a considerable pay-off, which generally requires little if any investment on the part of a producer. All that is

All that is generally needed to capture these additional profits is a herd health program that keeps cows in good health for six to seven lactations versus three or four.

## **Conclusions**

The results of this analysis of cow longevity suggest that under the assumption made here, the optimal holding period for the average cow is somewhere between 6 and 7 lactations. Results also show that holding periods for cows will be extended when the cost of replacement heifers is high or the milk price is relatively low. It was also found in this study that the optimal holding periods for lower producing herds may be shorter than those for lower producing herds in cases where replacement heifers are relatively expensive.

As a part of this analysis it was also determined that the current practice of culling 33 percent or more of dairy herds annually may be annually costing dairy producers \$50 to \$100 of potential returns per cow. These economic losses represent gains that producers could capture if they improve their herd management practices and get their culling rates down. Hopefully this analysis will help producers aware of the costs associated with high culling rate in their dairy herds and motivate them to manage their culling activities.



<b>Table 1: Income and Cost ( In Dollars ) Estimates Used For The Analysis</b>										
	----- Lactation: -----									
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
Milk Income	2901.18	3413.15	3402.22	3353.15	3266.09	3141.24	2978.75	2778.80	2541.56	2267.21
Calf Income	62.17	62.17	62.17	62.17	62.17	62.17	62.17	62.17	62.17	62.17
Feed Costs	-1080.82	-1271.55	-1270.33	-1261.09	-1243.83	-1218.54	-1185.24	-1143.93	-1094.59	-1037.23
Var. Oper. Costs	-205.85	-205.85	-205.85	-205.85	-205.85	-205.85	-205.85	-205.85	-205.85	-205.85
Labor	-456.35	-456.35	-456.35	-456.35	-456.35	-456.35	-456.35	-456.35	-456.35	-456.35
Breeding	-24.45	-24.45	-25.06	-25.69	-26.33	-26.99	-27.67	-28.36	-29.07	-29.79
Health	-84.20	-84.20	-86.30	-88.46	-90.67	-92.94	-95.26	-97.64	-100.09	-102.59
Dry Period Costs	-131.75	-131.75	-131.75	-131.75	-131.75	-131.75	-131.75	-131.75	-131.75	-131.75
Net Returns	979.93	1301.17	1288.75	1246.13	1173.49	1070.99	938.80	777.10	586.05	365.82

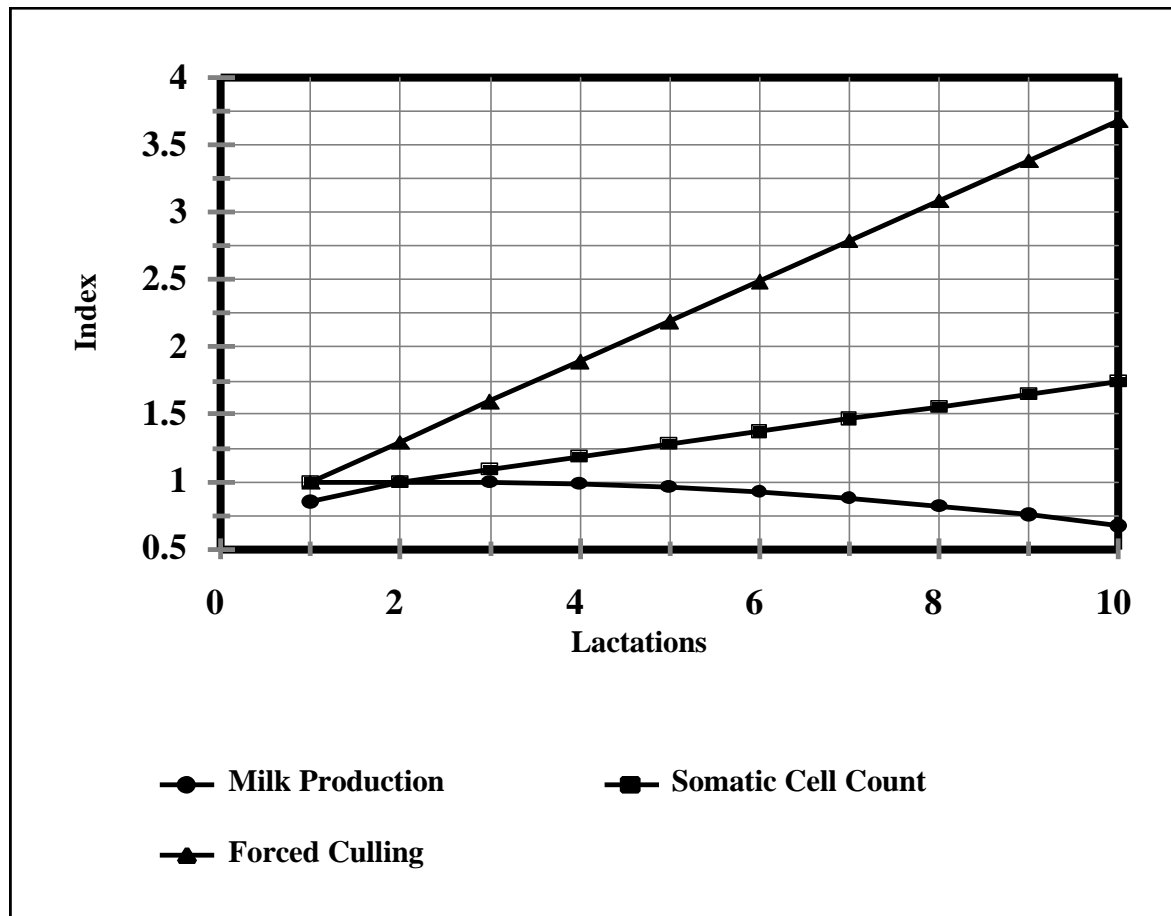
<b>Table 2: Optimal Culling Rates and Other Performance Measures For Dairy Cows Annually Producing 26,014 Pounds Of Milk In Their Second Lactation Under Various Milk Prices and Replacement Costs</b>			
	Per Head Replacement Cost (\$):		
	1200	1500	1800
Results For \$11 Milk Price:			
% Heifers ( Culling rate )	24.41	22.91	22.91
Maximum Lactations Achieved	6.00	7.00	7.00
% Herd Achieving Maximum Lactations	9.01	6.18	6.18
Average Lactations Per Head	2.95	3.20	3.20
Net Annual Return (\$)	411.63	345.97	282.34
Results For \$13 Milk Price:			
% Heifers ( Culling rate )	24.41	22.91	22.91
Maximum Lactations Achieved	6.00	7.00	7.00
% Herd Achieving Maximum Lactations	9.01	6.18	6.18
Average Lactations Per Head	2.95	3.20	3.20
Net Annual Return (\$)	844.31	776.63	713.00
Results For \$15 Milk Price:			
% Heifers ( Culling rate )	24.41	24.41	22.91
Maximum Lactations Achieved	6.00	6.00	7.00
% Herd Achieving Maximum Lactations	9.01	9.01	6.18
Average Lactations Per Head	2.95	2.95	3.20
Net Annual Return (\$)	1276.99	1209.16	1143.66

**Table 3: Optimal Culling Rates and Other Performance Measures For Dairy Cows Annually Producing 26,014 Pounds and 22,664 Pounds Of Milk, Respectively, In Their Second Lactation Under Various Milk Prices**

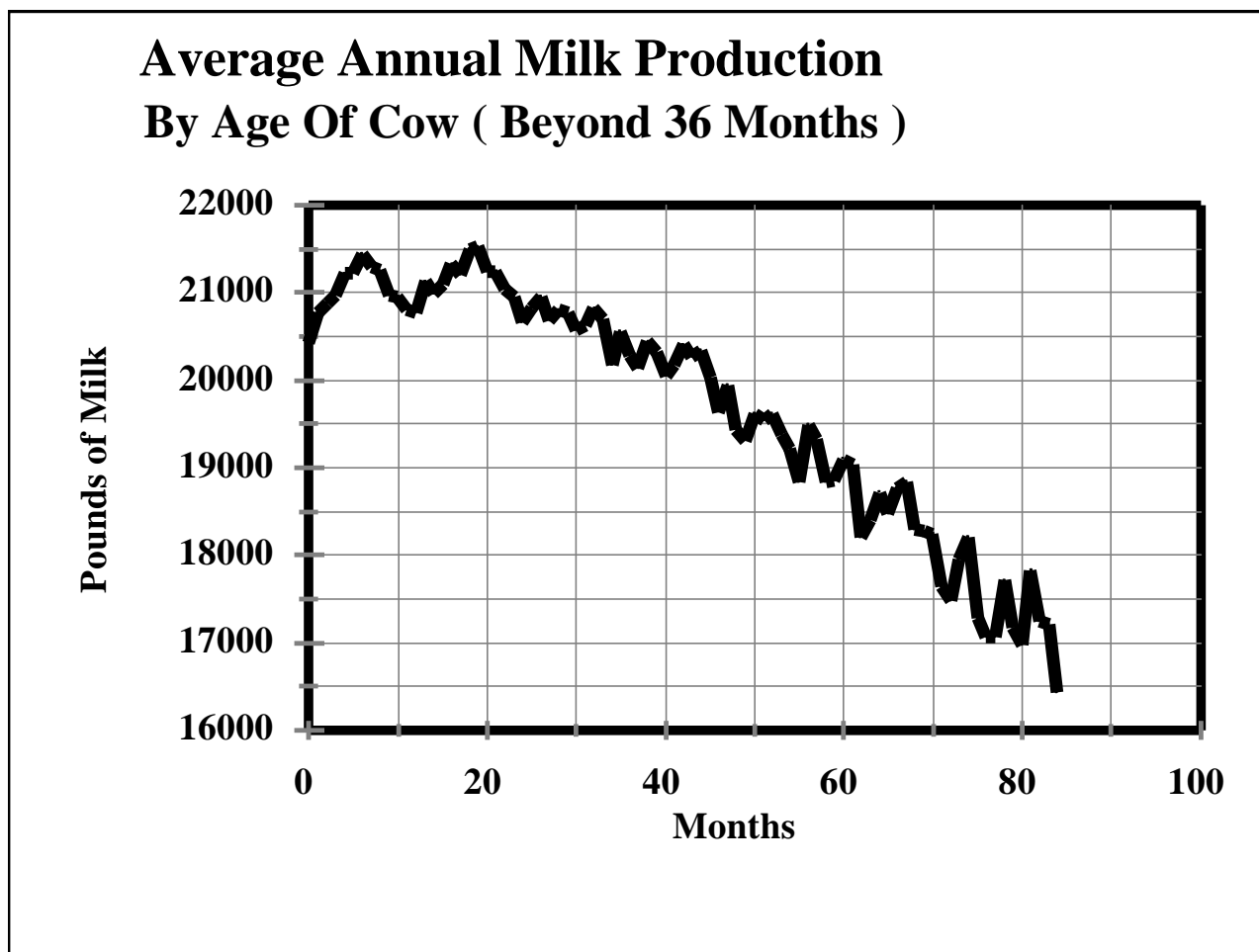
	Total Annual Pounds Milk Production Of:	
	26,014	22,664
Results For \$11 Milk Price:		
% Heifers ( Culling rate )	22.91	21.95
Maximum Lactations Achieved	7.00	8.00
% Herd Achieving Maximum Lactations	6.18	4.15
Average Lactations Per Head	3.20	3.40
Net Annual Return (\$)	282.34	46.87
Results For \$13 Milk Price:		
% Heifers ( Culling rate )	22.91	22.91
Maximum Lactations Achieved	7.00	7.00
% Herd Achieving Maximum Lactations	6.18	6.18
Average Lactations Per Head	3.20	3.20
Net Annual Return (\$)	713.00	422.20
Results For \$15 Milk Price:		
% Heifers ( Culling rate )	22.91	22.91
Maximum Lactations Achieved	7.00	7.00
% Herd Achieving Maximum Lactations	6.18	6.18
Average Lactations Per Head	3.20	3.20
Net Annual Return (\$)	1143.66	797.59

<b>Table 4: Net Annual Returns and Other Performance Measures For A Culling Rate Of 33% An Optimal Rate of Culling Under Various Replacement Costs</b>			
	Per Head Replacement Cost (\$):		
	1200	1500	1800
<b>Results For Culling Rate of 33%</b>			
% Heifers ( Culling rate )	33.00	33.00	33.00
Maximum Lactations Achieved	4.00	4.00	4.00
% Herd Achieving Maximum Lactations	13.27	13.27	13.27
Average Lactations Per Head	2.18	2.18	2.18
Net Annual Return (\$)	793.57	701.89	610.22
<b>Results For Optimal Culling Rate</b>			
% Heifers ( Culling rate )	24.41	22.91	22.91
Maximum Lactations Achieved	6.00	7.00	7.00
% Herd Achieving Maximum Lactations	9.01	6.18	6.18
Average Lactations Per Head	2.95	3.20	3.20
Net Annual Return (\$)	844.31	776.63	713.00
Economic Loss From Culling Above Optimal Rate (\$)	-50.74	-74.74	-102.78

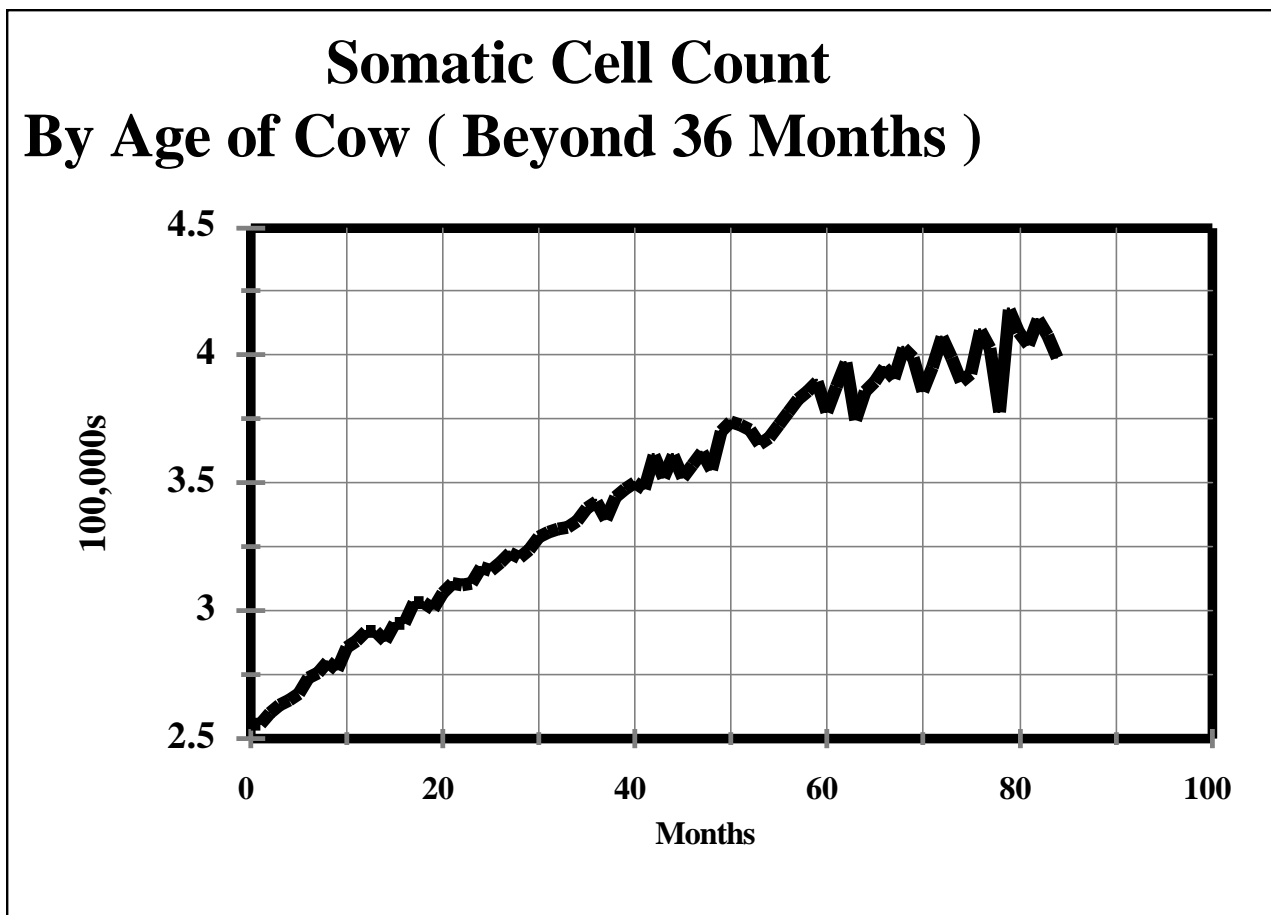
**Figure 1: Trends in Milk Production, Somatic Cell Count, and Forced Culling, Across Lactations, Assumed for the Purposes of the Analysis.**



**Figure 2: Average Annual Milk Production For Multiparous Cows  
36 Months Old Or Older**



**Figure 3: Average Somatic Cell Count For Multiparous Cows  
36 Months Old Or Older**



**Appendix 1 : Adjustments Made in Milk Production and Milk Price Over Lactations Based on the Trends Observed In DHI Test Dairy Herds ( Figures 1 and 2 )**

	Lactation	Calving Interval in Days						
		360	390	420	450	480	510	540
<b>Adjustments in Annual Milk Production</b>								
	<b>1</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>
	<b>2</b>	<b>0.9988</b>	<b>0.9983</b>	<b>0.9977</b>	<b>0.9970</b>	<b>0.9963</b>	<b>0.9955</b>	<b>0.9946</b>
	<b>3</b>	<b>0.9881</b>	<b>0.9854</b>	<b>0.9824</b>	<b>0.9791</b>	<b>0.9756</b>	<b>0.9718</b>	<b>0.9678</b>
	<b>4</b>	<b>0.9678</b>	<b>0.9612</b>	<b>0.9541</b>	<b>0.9463</b>	<b>0.9379</b>	<b>0.9290</b>	<b>0.9194</b>
	<b>5</b>	<b>0.9379</b>	<b>0.9259</b>	<b>0.9127</b>	<b>0.8985</b>	<b>0.8833</b>	<b>0.8670</b>	<b>0.8496</b>
<b>Adjustments in Annual Milk Price</b>								
	<b>1</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>	<b>1.0000</b>
	<b>2</b>	<b>0.9986</b>	<b>0.9985</b>	<b>0.9984</b>	<b>0.9983</b>	<b>0.9982</b>	<b>0.9980</b>	<b>0.9979</b>
	<b>3</b>	<b>0.9972</b>	<b>0.9970</b>	<b>0.9968</b>	<b>0.9966</b>	<b>0.9963</b>	<b>0.9961</b>	<b>0.9959</b>
	<b>4</b>	<b>0.9959</b>	<b>0.9955</b>	<b>0.9952</b>	<b>0.9948</b>	<b>0.9945</b>	<b>0.9941</b>	<b>0.9938</b>
	<b>5</b>	<b>0.9945</b>	<b>0.9940</b>	<b>0.9936</b>	<b>0.9931</b>	<b>0.9926</b>	<b>0.9922</b>	<b>0.9917</b>



**Long-Day Lighting in Dairy Barns** – See website:

[http://bse.wisc.edu/HFHP/tipsheets\\_html/dairytips/lighting.htm](http://bse.wisc.edu/HFHP/tipsheets_html/dairytips/lighting.htm)

**Concerned About Inbreeding?**  
**A Computerized Mating Program might be the Answer!**  
(appeared in Hoard's Dairyman in October 1999)

Dr. Kent Weigel  
Department of Dairy Science, University of Wisconsin

Each year, service sires are selected for hundreds of thousands of US dairy cows using computerized mating programs. Generally speaking, sires are chosen that will genetically repair faults in the physical appearance of the cows – hence, the term “corrective mating”. In recent years, an important new role has emerged for mating programs: controlling inbreeding.

Inbreeding occurs whenever the sire and dam are genetically related to each other. If they are close relatives, like siblings or first cousins, the herdsman or AI technician will often recognize this relationship and choose a different sire. But trying to avoid inbreeding by examining pedigrees is becoming more and more difficult. After forty years of AI use, today's dairy sires and cows have complex pedigrees with numerous common ancestors spanning many generations. A particular sire and cow may initially appear to be unrelated, but if they share several common ancestors three or four generations back, their offspring might suffer from inbreeding.

We occasionally hear that inbreeding is increasing in the US dairy cattle population, but why should farmers be worried about inbreeding? The reason is that every cow and bull carries many undesirable genes (often called “genetic recessives”) that can reduce health and productivity, and inbred animals have a better than average chance of inheriting the bad genes from both parents. For this reason, animals with high levels of inbreeding typically have lower milk production, more health problems, poorer reproduction, and shorter productive life. A recent study at Virginia Tech showed that a 1% increase in inbreeding costs the dairy producer about \$23 in lifetime net income per cow. So there's no question that inbreeding can cost the commercial producer big money. Management of inbreeding in herd replacements is possible, but it requires analysis of large pedigrees for every cow and each of her potential mates. This is where the computer comes into play.

In a recent study at the University of Wisconsin – Madison, we looked at the opportunity for managing inbreeding in a sample of 50 large registered Holstein and Jersey herds. The average inbreeding coefficient for all pregnancies currently carried by cows in these herds was 4.9% for Holsteins and 6.5% for Jerseys (pedigrees were traced back to 1960 for both breeds).

Our mission was to determine the role that computerized mating programs might play in controlling inbreeding in the next generation of replacement heifers. For each of the 50 herds, we chose a sample of potential service sires from the top half of the active AI list. Sample size was 40 bulls for Holsteins and 20 for Jerseys, and no single bull was allowed to mate more than 15% of the herd.

Next we selected the best service sire for every cow in each of these fifty herds, using three different computerized mating programs to do the job. The first mating program simply selected the service sire with highest Net Merit, without considering inbreeding of the calf. This is what a typical producer might do if he simply picked the best sires available and didn't worry about individually mating each cow. The second mating program again selected the service sire with highest Net Merit, but this time we specified the maximum level of inbreeding that would be allowed in the recommended mating. Inbreeding levels were set at 5%, 6%, or 7% for Holsteins and 8%, 9%, or 10% for Jerseys; any prospective mating with inbreeding higher than these levels was rejected. This is how most currently available mating programs work. The third mating program selected the service sire with highest Net Merit, after adjusting for expected inbreeding depression in the calf. We used the value of \$23 depression in lifetime income per 1% inbreeding that was discussed earlier. The three different mating programs were evaluated based on their ability to produce low levels of inbreeding in the calves, high Net Merit of the service sires, and high lifetime profitability of the female offspring.

Results are shown in Table 1 for Holsteins and Table 2 for Jerseys. Keep in mind that you can't compare Net Merit and expected lifetime profit across breeds, because each breed has a different genetic base. The first important point is that **computerized mating programs can effectively reduce inbreeding in the next generation of replacement heifers**. Average inbreeding of calves from

recommended matings was up to 40% lower when inbreeding was considered in the mating program. Interestingly, applying a maximum level of inbreeding for potential matings was a less effective way to reduce inbreeding than was selection for Net Merit adjusted for inbreeding depression. The reason is that the first type of program does not actually minimize inbreeding, it simply looks for any mating that gives less inbreeding than the user-specified value. For example, if you choose a maximum inbreeding level of 6%, then a mating that gives 5.9% inbreeding is fair game, even though different mating might give only 2% inbreeding. The second important point is that **allowing a little more inbreeding doesn't necessarily mean you'll end up with sires that have higher genetic merit**. Increasing the allowable inbreeding level from 5% to 7% in Holsteins or from 8% to 10% in Jerseys didn't increase the average Net Merit of selected sires, it just allowed more inbreeding (and less profit). Why? All bulls on the active AI list are highly selected, with many generations of popular sires in their pedigrees. Therefore, these bulls (as a group) have a high genetic relationship to the national dairy cow population. However, the average dairy cow is no more closely related to the top bull on the list than to an average bull from this group. The third important point is that **the best way to maximize profitability of the next generation of replacement heifers is to select for genetic merit adjusted for expected inbreeding depression**. Expected lifetime profit per heifer calf increased by \$9-\$37 in Holsteins and \$20-\$59 in Jerseys when a mating program that considered inbreeding was used. But lifetime profit was substantially higher when selection was based on Net Merit adjusted for inbreeding depression than when a user-specified inbreeding level was applied.

In summary, computerized mating programs are inexpensive and widely used. These programs are generally based on correcting faults in the physical appearance of the cow, but many programs now also consider the expected inbreeding of the calf. The potential economic benefits associated with controlling inbreeding using computerized mating programs are substantial. Although issues regarding long-term maintenance of genetic diversity in our dairy breeds can't be solved simply by using mating programs, today's dairy producer can effectively use mating programs to decrease inbreeding and increase profitability in his next generation of replacement heifers.

Table 1. Average inbreeding coefficient, Net Merit, and expected lifetime profit for a sample of 25 large registered Holstein herds mated to a sample of 40 active AI sires.

<u>Goal of the Mating Program</u>	<u>Inbreeding</u>	<u>Lifetime Net Profit</u>
Maximize Net Merit regardless of inbreeding	4.7%	\$0
Maximize Net Merit with less than 5% inbreeding	3.8%	+\$9
Maximize Net Merit with less than 6% inbreeding	4.1%	+\$14
Maximize Net Merit with less than 7% inbreeding	4.3%	+\$21
Maximize Net Merit adjusted for inbreeding depression	2.9%	+\$37

Table 2. Average inbreeding coefficient, Net Merit, and expected lifetime profit for a sample of 25 large registered Jersey herds mated to a sample of 20 active AI sires.

<u>Goal of the Mating Program</u>	<u>Inbreeding</u>	<u>Lifetime Net Profit</u>
Maximize Net Merit regardless of inbreeding	7.2%	\$0
Maximize Net Merit with less than 8% inbreeding	5.8%	+\$20
Maximize Net Merit with less than 9% inbreeding	6.1%	+\$26
Maximize Net Merit with less than 10% inbreeding	6.4%	+\$32
Maximize Net Merit adjusted for inbreeding depression	4.4%	+\$59

## NEW TECHNOLOGIES IN CALF MANAGEMENT AND NUTRITION

**Patrick C. Hoffman**  
**Dairy Specialist**  
**Department of Dairy Science,**  
**University of Wisconsin-Madison**

### **Introduction**

There have been a number of recent advances in dairy calf nutrition and management. Many of the advances are simply a concerted effort to apply research-proven practices that producers were reluctant to implement in the past. Below is a condensed list of new technologies that are having a significant impact on the calf rearing industry.

### **New Technologies – Calf Nutrition**

In cold climates, two common scenarios exist in calf nutrition. First, maintenance energy requirements increase when calves are reared in cold housing systems (Catell, 1999). Second, calves are generally program fed 1 lb of milk replacer powder per day. Under these scenarios, the only possible method to meet the increased environmental energy demand is to increase the energy density of the milk replacer. The most logical method of increasing milk replacer energy density is to increase the fat content of the milk replacer. Research evaluating increasing fat content in calf diets in cold weather environments has generally demonstrated indifferent results. Scibilia et al. (1987) fed calves 10.0, 17.5, or 25.0% dietary fat for 3 weeks. Calves were housed at temperatures of 25E or 50E F. There was a positive relationship between dietary fat and growth of calves at 25E F, but increasing dietary fat had little effect on growth rate when calves were housed at 50E F (Table 1).

Jaster et al. (1990) fed calves approximately 1 lb of dry matter from whole milk or milk replacer with or without .25 lb/d of a 60% fat supplement. There were no differences in calf growth between calves fed milk and milk replacer, but growth rates were increased when .25 lb/d of supplemental fat was fed (Table 2). Schingoethe et al. (1986) fed calves 1 lb of milk solids from whole milk with and without .25 lb of a fat supplement during cold weather. Calves (1 to 5 wks) supplemented with additional fat gained 1.27 lbs/d and 1.04 lbs/d as compared to unsupplemented calves. From these data (Scibilia et al., 1987; Jaster et al., 1990; Schingoethe et al., 1986) it appears increased fat supplementation results in some positive calf growth effects during cold weather. While data suggest significant positive effects of fat supplementation on calf growth during cold weather, the magnitude of the response is very small (.10 to .20 lb/d). In the case of Scibilia et al. (1987), increasing dietary fat from 10.0 to 25.0% only alleviated complete negative energy balance. Further increasing dietary fat during cold weather may yield calves at 35d that are 3.5 to 7.0 lbs heavier than unsupplemented calves. In the author's opinion, manipulation of dietary fat during cold weather may be helpful, but its net effects are minor. It should come to question whether increasing milk replacer fat content is the most economical management practice available in cold climates.

In addition, manipulation of dietary fat in milk replacers during summer months in cold climate regions yields little benefit. Minnesota workers (Kuehn et al., 1994) fed calves high fat (21.6% and low fat (15.6%) milk replacers in combination with high fat (7.3%) and low fat (3.7%) calf starters during the spring, summer, and fall. In this study, there were trends of depressed starter intakes and growth rates when high fat levels were fed.

Another method to increase the dietary energy of calves is to increase the solids feeding rate. In a recent study at the University of Illinois (Drackley, 2000) calves were fed milk replacer solids at 10, 14, and 18% of BW for 7 wks (Table 3). Note the dramatic improvements in growth rates from a low of .60 lbs/d to a high of 2.25 lbs/d. The reader is cautioned that no starter was fed and calves were not challenged under cold climates. Despite shortcomings of practical application, the data of Drackley (2000) demonstrates that dietary energy status and growth rate can be dramatically influenced by altering the solids feeding rate. Currently there are a number of milk replacer companies offering milk replacers specially formulated to feed at higher rates. Special formulation is required because as growth is increased by feeding more milk replacer energy, more protein is required in the milk replacer to meet tissue demands. Milk replacer fed at 1, 2, or 3 lbs/d should contain 20, 25, and 30% CP, respectively (approximate). There have been numerous studies conducted on these practices and results have been consistently positive.

Recently in our laboratory (Sowinski, et al., 2002) we evaluated modest increases in milk replacer feeding rate and examined the effects on animal health. We fed calves either 1.0 or 1.25 lbs of milk replacer for 35 days. Calves fed the higher rate (1.25 lbs/day) of milk replacer powder had less scours and lower treatment cost than calves fed 1.0 lbs/day of milk replacer powder. These data indicate that enteric disease is not necessarily related to feeding more milk replacer.

### **New Technologies – Calf Housing**

The standard housing system for raising calves in northern climates has been the calf hutch. There have been numerous design modifications to the calf hutch such as round vs square, vents, front openings, size, color, parent building material. There is little evidence to suggest that any of these modifications to the original design (Brunsvold et al., 1985) make a major improvement upon the system. There are numerous examples in cold weather application of success and failure with any given calf hutch modification. The trend in northern climates has been to use a modified hutch concept (e.g., 4 x 8 ft pen) inside of a building to improve operator comfort during cold weather conditions. The buildings used are typically old stanchion barns, curtain sidewall frame buildings, greenhouse structures, or fabric covered structures. Again, there is no evidence to suggest that the type of parent building for modified indoor hutch systems has any profound effect on calf performance. However, continuous calf flow rearing, poor ventilation and improper management of resting areas in these systems can dramatically increase the risk for acute and chronic disease problems. Recently calf producers in northern climates with modified indoor hutch systems have adopted all in all out (AIAO) management strategies for the facilities. The AIAO management system allows for proper clean up, rest time, etc., to decrease pathogen load in the facility. A second system to the AIAO system has also emerged, that being extreme over capacity (25 to 50%) in individual calf units (modified hutches). In this system, no individual calf housing unit ever has a calf put in it without a 2 to 3 week rest period. In some cases, dual calf housing systems are used whereby calves are reared in traditional calf hutches

outside in the summer and in inside modified hutches in the winter, again breaking pathogen cycles in the total calf housing system.

### **New Technologies – Biological Tests**

Specific tests to evaluate colostrum management of newborn calves is not necessarily new technology, but the use of these tests has increased dramatically in the past few years. Calves require passive transfer of antibodies from colostrum for disease protection. Adequate passive transfer depends on the amount of colostrum, quality of colostrum, and the time fed after birth. To eliminate the guess work on passive transfer of antibodies to calves, tests are available to evaluate whether adequate passive transfer has taken place. Perhaps the simplest of these tests is a serum refractometer which measures serum protein levels. A serum refractometer is a low cost hand held device that can very accurately measure adequacy of passive transfer. A blood sample is drawn, centrifuged, and a drop of serum is evaluated for protein content. Elisa kits are now available to measure the immunoglobulin content of colostrum. The tests are quick, economical, and absolutely invaluable in calf management.

### **New Technologies – Colostrum Odds and Ends**

For many years, freezing high quality colostrum was a recommended practice to safeguard against a future calving where colostrum quality was poor. It still is an excellent practice; however, if possible colostrum should be refrigerated. Freezing colostrum has been shown to damage the white blood cells in colostrum which also aid in immune function of the calf. Colostrum can be safely refrigerated up to one week. Do not refrigerate antibiotic or blood contaminated colostrum.

In addition, the practice of feeding 4 quarts of colostrum either bottle fed or via esophageal feeder 1 hour after birth is gaining wide acceptance in the industry. While data is limited, it appears this practice is producing superior results as compared to the old practice of feeding 2 quarts of colostrum 2 x 12 hrs apart.

### **New Technologies – Oral Immunoglobulin Supplements**

Immunoglobulin supplements have been around for some time, but their value, quality, and use are continually changing. The gold standard of the industry is still high quality colostrum, but when situations warrant, colostrum supplements can aid in stimulating calf immune function. New manufacturing and protein fractionation processes have helped evolve the viability of colostrum supplements. New classes of oral immunoglobulin supplements (Gammulin®) are also on the market. These products are fed as a continuous supplement for approximately 14 to 21 days. The globulin proteins work by moving into the gut and assist in immune response to intestinal pathogens. They are not absorbed as in the case of colostrum immunoglobulins. Recent data from Quigley et al., 2001 demonstrated that globulin proteins increase calf growth and decrease scours and death loss.

TABLE 1. Average daily gains of calves fed milk replacers of different fat contents for 3 wk (Scibilia et al., 1987).<sup>1</sup>

Dietary Fat, %	Temperature EF	
	25	50
10.0	-0.08	0.33
17.5	0.04	0.48
25.0	0.19	0.44

<sup>1</sup> No calf starter fed.

TABLE 2. The effect of fat supplementation on calf growth during cold weather (Jaster et al., 1990).

Item	Milk	Milk + Fat	Replacer	Replacer + Fat
Liquid intake, lb/d	1.0	0.95	0.92	0.96
Fat supplement, lb/d	0.0	0.25	0.0	0.25
Starter intake, lb/d	0.40	0.54	0.57	0.45
Gain, lbs/d	0.23	0.35	0.27	0.43

TABLE 3. Effects of feeding rate and crude protein (CP) content of milk replacers on average daily gain (ADG) and final whole-body composition in male Holstein calves (Drackley, 2000, unpublished data).

Feeding rate (% of BW)	CP content (%)	ADG (lbs/d)	Final whole body composition (%)		
			Water	Protein	Fat
10	14	0.60	71.7	17.3	7.1
10	18	0.68	72.8	17.5	5.9
10	22	0.90	73.0	17.8	5.6
10	26	0.79	73.5	17.9	5.1
14	14	1.12	70.6	16.8	8.8
14	18	1.32	71.6	17.1	8.1
14	22	1.52	72.8	17.4	7.1
14	26	1.55	71.8	17.7	6.6
18	26	2.25	71.6	17.2	7.6

The effects of intake and the linear effect of increasing dietary CP were significant ( $P < 0.05$ ).

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