

Section A				
Wednesday				
8:00	Welcome			
8:10		No Room at the Inn: Stocking Density and Time Budgets	Rick Grant	Miner Institute
8:50		Animal Welfare: How Can We Assure the Consumer?	Jim Reynolds	University of California- Davis
9:30		Making the Most from Manure	Deanne Meyer	University of California
10:10	Break			
10:30		The Latest on Cross Ventilation of Barns—Panel Discussion	Joe Harner	Kansas State University
11:30		Improving Dairy Cattle Welfare: Implications of Freestall Housing on Behavior and Health	Marina von Keyerlinkgk	University of British Columbia
12:10	Lunch			
1:40		Straddling the Barbwire Fence: How Dairy Farmers Can Legally Employ Immigrant Labor	Ben Yale	Yale Law Office
2:20		Production and Markets: What Part of the Roller Coaster are We on?	Mary Ledman	Keough Ledman Associates
3:00	Break			
3:30		Recognizing Stress, Anger, Depression, and Suicidal Thinking and Knowing What to do Next?	Robert Fetsch	Colorado State University
4:10		The Future of Ag Biotechnology: Who Prevails?	Terry Etherton	Pennsylvania State University
4:50		The Latest on Transition Cow Management	Mike Overton	University of Georgia
5:30	Adjourn			
Thursday				
7:30		Reproductive Efficiency and Economics of Timed AI vs. Natural Service	Carlos Risco	University of Florida
8:10		Heat Detection and AI Technician Evaluation	Joe Dalton	University of Idaho
8:50		National Heifer Supply and the Effects of Sexed Semen	Albert DeVries	University of Florida
9:30	Break			
10:00		Managing the Costs of Cow Mortality	Frank Garry	Colorado State University
10:40		What's the Connection Between Animal Diseases and Consumers?	Bill Sischo	Washington State University
11:20		On Farm Culturing the Better Milk Quality	Pam Ruegg	University of Wisconsin
12:00	Lunch			
1:30		Managing Feed and Milk Price Risk: Futures Markets and Insurance Alternatives	Dillon Feuz	Utah State University
2:10		How to Make ID Technology Work for You	Matt VanBaale	UltiMilk Dairy Company
2:50	Break			
3:30	DMI Panel	Assuring Dairy's Viability in a Changing World: <ul style="list-style-type: none"> <li>Dairy/Consumer Trends and the Resulting Agriculture and Dairy Disconnects, Challenges and Opportunities</li> <li>"Building Bridge" from Trends and Issue to Positive Dairy Action</li> <li>Animal Well Being and Maintaining Dairy's Social License</li> <li>Dairy Sustainability Issues and Initiatives</li> <li>Dairy Production Technologies, Challenges, and Opportunities</li> <li>Human Resource Issues Facing the Dairy Industry</li> </ul>	Charlie Arnot Stan Erwine Jan Shearer Rick Naczi Gatz Riddell Jorge Estrada	CMA Dairy Management, Inc. University of Florida Dairy Management, Inc. AABP Leadership Coaching Intn'l
5:30	Adjourn			
Friday				
8:00		Is a One TMR Approach Right?	Mike Hutjens	University of Illinois
9:00		The Effects of Heat Stress on Nutritional and Management Decisions	Lance Baumgard	University of Arizona
9:40		Feeding \$10/Bushel Corn for Fun and Profits	Normand St. Pierre	Ohio State University
10:20		Solving Bad Water Problems for Thirsty Cows	David Beede	Michigan State University
11:00		Don't Let Shrink Kill You with High Feed Prices	Mike Brouk	Kansas State University
11:40	Adjourn			

<b>Section B</b>				
<b>Wednesday</b>				
8:00	Welcome			
8:10		Reproductive Efficiency and Economics of Timed AI vs. Natural Service	Carlos Risco	University of Florida
8:50		Heat Detection and AI Technician Evaluation	Joe Dalton	University of Idaho
9:30		National Heifer Supply and the Effects of Sexed Semen	Albert DeVries	University of Florida
10:10	Break			
10:30		Improving Dairy Cattle Welfare: Implications of Freestall Housing on Behavior and Health	Marina von Keyerlinkg	University of British Columbia
11:10		The Latest on Transition Cow Management	Mike Overton	University of Georgia
11:50	Lunch			
1:20		Production and Markets: What Part of the Roller Coaster are We on?	Mary Ledman	Keough Ledman Associates
2:00		Animal Welfare: How Can We Assure the Consumer?	Jim Reynolds	University of California- Davis
2:40		Straddling the Barbwire Fence: How Dairy Farmers Can Legally Employ Immigrant Labor	Ben Yale	Yale Law Office
3:20	Break			
3:50		Managing the Costs of Cow Mortality	Frank Garry	Colorado State University
4:30		The Latest on Cross Ventilation of Barns—Panel Discussion	Joe Harner	Kansas State University
5:30	Adjourn			
<b>Thursday</b>				
7:30		Recognizing Stress, Anger, Depression, and Suicidal Thinking and Knowing What to do Next?	Robert Fetsch	Colorado State University
8:10		The Future of Ag Biotechnology: Who Prevails?	Terry Etherton	Pennsylvania State University
8:50		Making the Most from Manure	Deanne Meyer	University of California
9:30	Break			
10:00		No Room at the Inn: Stocking Density and Time Budgets	Rick Grant	Miner Institute
10:40		How to Make ID Technology Work for You	Matt VanBaale	UltiMilk Dairy Company
11:20		Managing Feed and Milk Price Risk: Futures Markets and Insurance Alternatives	Dillon Feuz	Utah State University
12:00	Lunch			
1:30		What's the Connection Between Animal Diseases and Consumers?	Bill Sischo	Washington State University
2:10		On Farm Culturing the Better Milk Quality	Pam Ruegg	University of Wisconsin
2:50	Break	Please See Section A		

***Meal Sponsors***

CHR Hansen, Inc. (\$5,000)  
Elanco (\$7,500)

***Reception Sponsors***

Intervet/Schering Plough A-H  
Pfizer Animal Health

***Break Sponsor***

Dairy Management, Inc. (Cheese)

***Platinum Sponsors (\$3,000)***

Alltech  
Arm & Hammer® Animal Nutrition Group  
Bou-Matic  
Cargill Animal Nutrition  
Dairy Farmers of America, Inc.  
Diamond V® Mills  
Fort Dodge Animal Health  
GEA Farm Technologies / WestfaliaSurge  
Intervet/Schering Plough A-H  
Land O'Lakes Purina Feeds, LLC  
Mycogen Seeds  
Performance Products, Inc.  
Pfizer Animal Health  
Pioneer Hi-Bred  
Rabobank / Rabo AgriFinance  
West Central Coop  
Zinpro Performance Minerals

***Gold Sponsors (\$1,500)***

A.L. Gilbert Co.  
ABS Global, Inc.  
Aerotech Ventilation Systems  
Ag Processing Inc. / Amino Plus  
AgriLabs®  
Associated Feed  
Balchem  
Calf-tel by Hampel Corp.  
DeLaval, Inc.  
DHI-Provo  
Farm Credit of New Mexico  
Laird Manufacturing

Schaefer Ventilation Equipment  
Standard Dairy Consultants  
Virtus Nutrition, LLC

***Silver Sponsors (\$750)***

Accelerated Genetics  
Agpro, Inc.  
Beco Dairy Automation, Inc.  
Biomim, USA  
BioTracking, LLC  
CRI  
Dairy Enterprise Services  
Dairy Records Management Systems  
Dairy Works, LLC  
Edstrom Industries, Inc.  
Feedstuffs  
Global Dairy Systems  
I.D. Ology  
J & D Manufacturing  
McLanahan Corporation  
Milk-Rite USA  
Min-AD, Inc.  
MultiMin® USA, Inc.  
Novus International  
Paul Mueller Company  
Poultry Protein & Fat Council  
Roto-Mix  
Select Sires, Inc.  
Soy Best  
Tom Fuhrmann, DVM  
Western KS Rural Economic Development  
Alliance  
Western Yeast Company

***Media Sponsors (Advertising)***

DairyCast  
Dairy Herd Management  
Dairy Today  
Hoard's Dairyman  
Hoard's WEST  
Progressive Dairy Publishing  
Western DairyBuisness  
2009 Sponsors



## **2009 Western Dairy Management Conference Proceedings**

*Welcome to the Western Dairy Management Conference- Thank you for attending. Please turn off or silence your cell phone during presentations. Video taping is not allowed. Each author's permission is required for the use of their visuals.*

### Page

- 7 Stocking Density and Time Budgets**  
Rick Grant, Miner Institute
- 19 Making the Most from Manure**  
Deanne Meyer, University of California
- 27 In the Thermoneutral Zone: Potential Benefits of LPCV Buildings**  
Joe Harner, Kansas State University
- 43 Improving the Welfare of Dairy Cattle: Implications of Freestall Housing on Behaviors and Health**  
Marina von Keyserlinkgk, University of British Columbia
- 53 Employing Aliens: Straddling the Barbed Wire Fence**  
Ben Yale, Yale Law Office
- 75 Recognizing Stress, Anger, Depression, and Suicidal Thinking and Knowing What to do Next?**  
Robert Fetsch, Colorado State University
- 83 The Future of Ag Biotechnology: Who Prevails?**  
Terry Etherton, Pennsylvania State University
- 91 Transition Management Checklist**  
Mike Overton, University of Georgia
- 103 Reproductive Efficiency and Economics of Timed AI vs. Natural Service**  
Carlos Risco, University of Florida

- 117 Heat Detection Accuracy and AI Technician Evaluation**  
Joe Dalton, University of Idaho
- 131 National Heifer Supply and the Effects of Sexed Semen**  
Albert DeVries, University of Florida
- 141 Adult Dairy Cow Mortality**  
Frank Garry, Colorado State University
- 145 What's the Connection Between Animal Diseases and Consumers?**  
Bill Sischo, Washington State University
- 149 On Farm Culturing for Better milk Quality**  
Pam Ruegg, University of Wisconsin
- 161 Managing Feed and Milk Price Risk: Futures Markets and Insurance Alternatives**  
Dillon Feuz, Utah State University
- 175 How to Make ID Technology Work for You**  
Matt VanBaale, UltiMilk Dairy Company
- 185 Is a One TMR Approach Right?**  
Mike Hutjens, University of Illinois
- 191 The Effects of Heat Stress on Nutritional and Management Decisions**  
Lance Baumgard, University of Arizona
- 203 Feeding \$10 Corn for Fun and Profit**  
Normand St. Pierre, Ohio State University
- 217 Solving Bad Water Problems for Thirsty Cows**  
David Beede, Michigan State University
- 227 Don't Let Shrink Kill You with High Feed Prices**  
Mike Brouk, Kansas State University

# Stocking Density and Time Budgets

Rick Grant  
W. H. Miner Agricultural Research Institute  
P. O. Box 90  
Chazy, NY 12921  
Phone: 518-846-7121 x116  
Fax: 518-846-8445  
Email: grant@whminer.com

## Dairy Cow's Daily Time Budget

Essentially, the 24-h time budget represents the net response of a cow to her environment. Deviations in any herd from these benchmarked behavioral routines represent departures from natural behavior and can serve as a basis for estimating the performance and economic loss due to poor management strategies. Table 1 illustrates a simplified daily time budget for lactating dairy cattle adapted from Grant and Albright (2000) for cows in a free-stall environment.

Table 1. Typical daily time budget for lactating dairy cow.

Activity	Time devoted to activity per day
Eating	3 to 5 h (9 to 14 meals/d)
Lying/resting	12 to 14 h
Social interactions	2 to 3 h
Ruminating	7 to 10 h
Drinking	30 min
Outside pen (milking, travel time)	2.5 to 3.5 h

Albright (1993) measured the daily behavioral time budget for a cow (Beecher Arlinda Ellen) during the lactation in which she set a world record for milk production while housed primarily in a box stall. The data indicated that she spent 6.3 h/d eating, 13.9 h/d resting (lying), and 8 h/d ruminating (7.5 h/d while lying and 30 min/d while standing). Matzke (2003) compared the time budget of the top-10% of cows (by milk yield) in a group versus the average time budget for the entire group of cows. Table 2 compares the daily behavioral time budget for the highest milk production versus the average production cows. It is interesting that these elite cows, as well as Beecher Arlinda Ellen (the first cow to produce >50,000 lb of milk in a lactation), both rested for 14 h/d. One could speculate that the actual requirement for resting is close to 14 h/d for the most productive cows, rather than 10 to 12 h/d as commonly proposed. An appropriate analogy might be the approach of formulating rations to meet the requirements of a cow above the average milk production level in a group of cows. Perhaps we need to consider designing facilities and developing management routines that allow all cows access to stalls for up to 14 h/d; cows requiring less than this amount will use the time for other behaviors whereas the highest producers will have adequate access to stalls.

Table 2. Daily behavioral time budget for top-10% of cows by milk production and average milk production cows (h/d).<sup>1</sup>

Activity	Top-10%	Average
Eating at manger	5.5	5.5
Resting	14.1 <sup>a</sup>	11.8 <sup>b</sup>
Standing in alleys	1.1 <sup>b</sup>	2.2 <sup>a</sup>
Perching in stalls	0.5 <sup>b</sup>	1.4 <sup>a</sup>
Drinking	0.3	0.4

<sup>ab</sup>Means within a row differ ( $P < 0.05$ ).

<sup>1</sup>Adapted from Matzke (2003).

It is clear that cows need to accomplish certain behavioral activities each day, and we cannot allow our management routines to interfere. If we tally up the required number of hours each day to satisfy the basic behavioral needs, it approaches 20 to 21 h/d:

5 to 5.5 h/d for eating + 12 to 14 h/d for lying/resting (includes 6 h of rumination)  
+ 4 h/d for rumination while standing + 30 min/d for drinking

If we add in only 30 min/d for other activities such as grooming and other interactions, the total time required in the budget is 20.5 to 21.5 h/d (Grant, 1999). Given this absolute time budget need, it is easy to see how our management practices can very easily perturb the cow's normal time budget. In fact, if cows are kept outside of the pen and denied access to resources such as stalls, feed, and water for greater than approximately 3.5 h/d, then they will be forced to give up some other activity since there are only 24 hours in a day. Often, resting time or feeding time will be reduced with negative consequences for productivity and health. Improper grouping strategies that result in overcrowding and excessive time in holding pens are two common ways of upsetting the time budget and reducing herd productivity. Excessive time spent in headlocks (>1 hour/day), especially in the fresh pen, is another common way to interfere with the cow's time budget.

### **Natural Behavioral Needs of Dairy Cattle**

#### **Cows have a strong behavioral need to rest**

Recently, Jensen et al. (2004) demonstrated that cows have a very strong motivation to rest, and that this motivation to rest increases as the length of rest deprivation becomes greater. In fact, lying behavior has a high priority for cattle after relatively short periods of lying deprivation. Cows have a definite requirement for resting (lying down) that they attempt to achieve, even if it means giving up some feeding time. A key concept is that feeding and resting behavior are linked in dairy cattle. Numerous studies show that management factors that interfere with resting inevitably reduce feeding behavior as well. A classic paper published by Metz (1985) evaluated what cows would do when access to either rest (stalls) or feed (manger) was prohibited. Cows attempt to maintain a rather fixed amount of lying time, and their well-being is impaired when lying time is restricted for several hours (Metz, 1985). Within 10 h, approximately 50% of lost resting activity has been recouped in most cases (Metz, 1985). When lying and eating are restricted simultaneously, cows choose to rest rather

than eat, with an additional 1.5 h/d standing time associated with a 45-min reduction in feeding time (Metz, 1985). A similar relationship was observed by Batchelder (2000) where cows with a stocking density of 130% preferred using free stalls versus eating post-milking and spent more time in the alley waiting to lie down than eating when compared with a stocking density of 100%. We have observed similar responses in dairy cows in a recent study here at Miner Institute at 130% and 145% stocking density (Hill et al., 2006).

Resting and feeding behavior are even linked during the transition period. First-calf heifers and mature cows that had greater lying and ruminating activity on days -2 and -6 prepartum also had greater feed intake and milk yield during days 1 to 14 postpartum (Daniels et al., 2003). This relationship raises an important question: how do we motivate cows to rest and ruminate during the close-up period?

Cows require 12 to 14 hours/day of rest (lying down). Benefits of resting include: potentially greater milk synthesis due to greater blood flow through the udder, greater blood flow to the gravid uterus during late lactation, increased rumination effectiveness, less stress on the hoof and less lameness, less fatigue stress, and greater feed intake. Grant (2004) has proposed that each additional one hour of resting time translates into 2 to 3.5 more pounds of milk per cow daily. Figure 1 summarizes data from experiments conducted at Miner Institute between 1998 and 2004 and illustrates the relationship between resting time and milk yield.

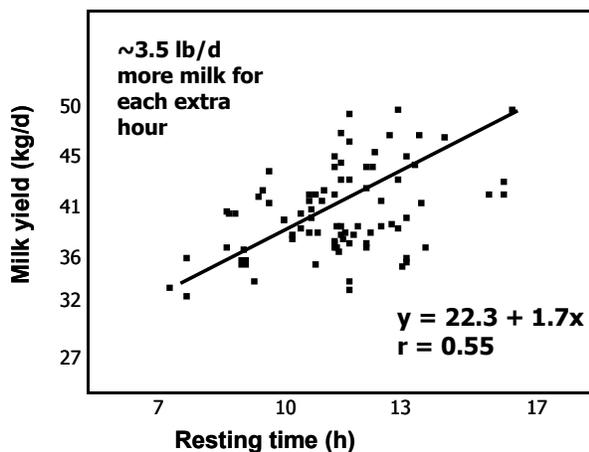


Figure 1. Relationship between resting time and milk yield in dairy cows (from Grant, 2004).

The bottom line is that lying has a higher priority than eating and social interactions for both early and late lactation dairy cows, and that cows compensate for reduced access to resting by spending less time eating to free up time for making up lost resting activity (Munksgaard et al., 2005). Interestingly, although little time is allocated to social contact with other cows, under conditions of limited access to feed and stalls, cows still defend their ability to have some social interactions – showing that they are social creatures.

### **Cows have a naturally aggressive feeding drive**

The naturally aggressive feeding drive of lactating dairy cows was best described by Dado and Allen (1994) when they concluded that higher producing (and typically older cows) eat more feed, eat larger meals more quickly, ruminate more efficiently, and drink more water more quickly than lower

producing (and typically younger cows). Some competition for feed is inevitable with dairy cows. Even with unlimited access to feed, cows interact in ways that give some cows an advantage over others (Oloffson, 1999).

A study conducted in 1998 provides the best illustration of the dairy cow's naturally aggressive feeding drive. In this study (Hansen and Pallesen, 1998) researchers measured the force applied to the feed barrier during eating. They observed that cows willingly exert greater than 500 pounds of force against the feed barrier in an attempt to reach as much feed in the bunk as possible. Pressure in excess of 225 pounds is sufficient to cause acute tissue damage – so cows will exert enough pressure to cause injury when trying to reach feed. This is perhaps the best illustration of the dairy cow's naturally aggressive feeding drive. We need to manage the feeding area and feed delivery system so that the cow does not need to exert these levels of force against the feed barrier while reaching for feed.

### **Grouping Strategies and Natural Behavioral Responses**

Recently, Boe and Faerevik (2003) published an excellent review of grouping and social responses in calves, heifers, and mature cows. Previously, Grant and Albright (2001) published a review specifically on effects of grouping strategy on feed intake in dairy cattle. A fundamental consideration for any decision tool on grouping strategies is the difference between conventional concepts in dominance hierarchies and grouping and what may be closer to reality. Conventionally, it is assumed that 1) cows fight to establish social hierarchy, 2) fighting stops once hierarchy is established, 3) dominant cows regulate access to the resources, 4) group size should not exceed number of cows an individual can recognize, 5) dominance hierarchy is rapidly established – 50% within one hour, and 6) the hierarchy is stable (only 4% are reversed). Contrast this rather static depiction of group interactions with the following more dynamic and likely realistic scenario: 1) continued and fluctuating levels of fighting/aggression, 2) formation of subgroups within larger pens, 3) inability to recognize all peers when group size exceeds approximately 100 cows, 4) some individuals thrive, not by winning fights, but by not participating, and 5) stable hierarchy formed within 2 d for cows with previous social experience and within 4 d for cows with no previous experience.

Achievement of social stability in a group of cattle is defined as when nonphysical agonistic interactions among group members predominate, and the ratio of physical to nonphysical interactions remains comparatively stable (Kondo and Hurnik, 1990). Various social behaviors and locomotor activity will return to a baseline level within 5 to 15 d following a grouping change such as regrouping or commingling (Boe and Faerevik, 2003). Essentially, this represents the major challenge inherent in grouping cattle. We need to manage a group of cows such that the rate of decline in physical interactions is as rapid as possible, and that the period of social stability is maximized. Realistically, animals move into and out of pens continuously on many farms, and so the challenge becomes managing the magnitude of increase in the physical interactions that accompany any regrouping and introduction of new animals into a pen. An especially good example of this continuously changing group situation is the fresh pen. A reasonable analogy would be steady state conditions in the rumen – they are never truly achieved, just assumed.

Early decision-support tools to help with grouping decisions may assume that social stability is reached and then is maintained, but this would clearly be simplification of reality. Monitoring and

then devising means to control the physical:nonphysical interaction ratio would be a valuable tool for producers and consultants. Classic data such as that reported by Krohn and Konggard (1980; cited in Grant and Albright, 2001; Table 4) provides useful information for modeling changes in resting, feeding, and other activity that occurs over time with regrouping. We need similar data from cows managed in larger groups.

A useful tool to assist with proper grouping decisions would need to consider competition for resources, stocking density, group size (and can it become too large?), group composition (especially primi- and multiparous cows commingled), and degree of commingling and movement between groups, particularly during the transition period when feeding behavior is naturally depressed. A tool that would accurately predict the net effect of these factors on the time budget, assuming deviations from a natural time budget can be related to changes in health and performance, would be a logical research goal.

### **Stocking Density and Cow Behavioral Responses**

Stocking density will affect the time budget of dairy cattle. To-date, relatively few experiments have evaluated stocking density, and most were conducted using small numbers of animals per pen. Consequently, the real effect of stocking density on larger group sizes remains unknown. A key difference between small group sizes and larger (more realistic) group sizes is the amount of time that an animal will spend outside the pen for milking and other management procedures. When cows spend too much time away from the pen (basically more than 3.5 h/d), resting time will be reduced (Matzke et al., 2002). Additionally, when primi- and multiparous animals are commingled, resting time is reduced much more for the heifers than for older cows (-2.6 h/d for multiparous cows and -4.2 h/d for primiparous cows; Matzke, 2003).

Table 3 summarizes the influence of stocking density of dairy cow behavior from the few reports in the literature. Although there is clearly variation among studies, the few data reported thus far are surprisingly consistent. One point of difference is between Wierenga and Hopster (1990) and the other reports for the effect of stocking density on resting. They found relatively little impact of overstocking on resting, which differs substantially from other reports. Some tentative conclusions to draw from these studies are: 1) at 120% stocking density and beyond, resting time is reduced by 12 to 27% (may be a function of pen size with greater reduction for larger pens), 2) eating time is not affected greatly by stocking density (although meal patterns and feed intake may well be), 3) rumination may be reduced by as much as 25% at 130% stocking density, and 4) at 120% stocking density or greater, standing time will be increased by 15 to 25%. In general, the negative effect of overstocking beyond ~120% on resting and standing becomes more pronounced as the level increases, but there is insufficient data with larger group sizes to accurately model the effect at this point.

Table 3. Stocking density (relative to stalls) and relative behavioral responses with responses to 100% stocking density set to 1.00.

Citation	SD (%)	Resting	Eating	Ruminating	Standing
Batchelder (2000)	100		1.00	1.00	
	130		0.95	0.75	
Winkler et al. (2003)	66	1.02			0.95
	100	1.00			1.00
	150	0.88			1.22
Fregonesi et al. (2004)	100	1.00			1.00
	110	0.92			1.12
	120	0.88			1.15
	135	0.84			1.19
	150	0.80			1.25
Wierenga and Hopster (1990)	100	1.00	1.00		1.00
	125	1.00	1.04		1.25
	133	0.98	0.95		1.52
	155	0.93	1.01		1.46
Matzke and Grant (2002)	85	0.95	1.02		0.95
	100	1.00	1.00		1.00
	120	0.73	1.02		1.20

### Grouping of Cows and Heifers

Most of us are aware of the recommendation to group first-lactation heifers separately from mature cows. Various studies have shown that heifers housed separately have greater DMI and higher productivity than those housed in mixed groups, but why is this? Research from the 1970s showed a 10 to 15% improvement in eating and milk yield when first-calf heifers were grouped separately from older cows. There was a nearly 20% increase in resting activity when heifers were housed separately.

The common thinking is that, since heifers are smaller, they have more difficulty competing for feed. While this is often true, recent research has shown that there are actually many more differences between heifers and mature cows than we may have suspected.

For example, heifers take smaller bites and spend more time feeding than mature cows. Since mature cows are usually more dominant and can push heifers away from feeding spaces, grouping them separately may ensure that heifers have enough time to feed throughout the day. Recent Spanish work found that heifers grouped separately ruminate more and drink more. A companion study to this work published in the January issue of the *Journal of Dairy Science* (Bach et al., 2006) indicated that housing heifers separately may also provide the added benefits of increased efficiency of fat-corrected milk production and less body weight loss in the first month of lactation. The improvement in milk fat production might be associated with both the increase in rumination and greater number of meals per day observed in heifer-only groups.

Resting behavior can also be affected in mixed groups. Cows do not perceive all stalls equally. Research has shown that dominant, mature cows will lie in stalls nearest the feed manger, while heifers tend to lie in stalls along the back wall. The heifers that do lie in the stalls nearest the feed bunk ruminate less than those lying along the outside wall, perhaps indicating that they are stressed by the thought that an older cow might kick them out at any time. British researchers have also observed signs of stress exhibited by heifers in mixed groups such as more time spent fighting and grooming than heifers grouped separately.

Grouping heifers separately is particularly important in overcrowded situations. Subordinate animals are the first to be affected as stocking rates increase beyond 100%. Although we need to study it further, here at Miner Institute we recently found that increased stocking rates reduced time spent lying by heifers more than cows. It also appears that heifers decrease rumination more than cows as stocking rate increases, which complements the research mentioned earlier. If our results prove true, reduced rumination and a possible increase in feeding rate may result in acidosis. Combined with increased time spent standing, this could create a perfect storm and increase lameness in heifers just as we want them to start paying off all of the costs we just put into raising them.

We also observed a potential decrease of up to 18 pounds of milk per day for the heifers compared with the cows as the stocking rate increased to 131 and 142%. It will take a long time for a heifer to pay for herself with that extent of reduction in milk yield.

### **Stocking Density, Cow Behavior, and Performance during Transition Period**

Research published during the past years illustrates the importance of creating the right environment for the transition cows in order to motivate them to be productive and healthy herd members. Major factors to consider are the natural behavioral patterns of transition cows, stocking rate, and grouping strategy of the close-up and fresh cow pens. Feeding, resting, and ruminating activity all decrease, and standing time increases, right at parturition. Also, we need to focus on the time spent managing transition cows. That time typically increases from virtually none to as much as several hours after calving. We need to keep in mind that cows cannot be out of their pens and away from their resources for more than 3.5 h/d or else they will be forced to take time out of required activities such as resting or eating.

Researchers at the University of Wisconsin Veterinary School evaluated the effect of overcrowding on the prefresh, close-up pen. In their study, the pens contained both first-calf heifers and older cows. When stocking density was greater than 80% of stalls in the prefresh group of mixed cows and heifers, milk yield was reduced for the heifers during the first 83 days in milk following calving. In fact, for each 10% increase in prefresh stocking density above 80%, there was a 1.6-pound per day reduction in milk yield for the first-calf heifers. These data need to be compared with older research that evaluated the impact of headlock stocking density on feed intake during the close-up period. In this study, feed intake was markedly reduced at any manger stocking density greater than 90%.

Also, on-farm observations from Idaho showed a strong negative relationship between headlock stocking density in the close-up pen and incidence of abomasal displacements after calving (Kluth, 2005, personal communication). Whenever headlock stocking density was greater than 90%, then the incidence of DA's went up sharply. Clearly, the take-home message of this research is that

stocking density greater than 80 to 90% in the prefresh or close-up pen will result in lost milk production and greater fresh-cow health problems.

In the fresh-cow pen, there is less research, but still an indication that stocking densities less than 100% for both stalls and manger space will result in better feed intake, milk yield, and fewer health problems. Also, keeping first-calf heifers grouped separately from older cows in both the prefresh and postfresh pens will help to ensure better health and productivity of the first-lactation animals.

For cows beyond the fresh group, there is not as much information, but the data definitely show that beyond 120% overstocking of stalls that resting behavior usually drops off substantially. No doubt, there is considerable variability among farms, but if we are stocking are pens beyond 120%, then red flags need to be raised that a problem is much more likely.

For the transition period, monitoring milk yield can be a useful indicator of the overall effectiveness of the management system. Useful targets for both first-calf and mature cows for milk yield are:

- First lactation animals: target would be to observe an 8% increase in milk per day for the first 18 days of lactation. A problem exists if there is no increase in milk or milk yield is less than 65 pounds per day at 30 days in milk.
- For second and greater lactation animals, there should be a 10% increase in milk yield per day during the first 14 days of lactation. A problem exists if there is no increase in milk yield or if milk production is less than 85 pounds per day at 30 days in milk.

The bottom line is that stocking density of the transition pens is a key part of the management strategy. We have suspected this for a long while and now we have good evidence that we lose milk and suffer more health problems when we overstock the close-up and fresh cow pens. In fact, even 100% stocking rate is too high!

### **Recent Research on Stocking Density at Miner Institute**

Recently, we summarized all of the research that related stocking density with resting activity (Grant, 2004). As you can see, there is considerable variation in cow response to stocking rate, but it appears that things become interesting above 120% stocking rate. These studies show that eating time is not influenced by stocking rate (although eating rate surely can be affected) and rumination decreased by 25% at 130% stocking rate versus 100%. It is important to remember that our goal is not to achieve zero competition. In fact, some competition is inevitable. Even with unlimited access to feed, for instance, cows will interact in ways that give some an advantage over others (Oloffson, 1999).

We have just finished a study at Miner Institute that evaluated the effect of 100, 115, 130, or 145% stocking density of stalls and manger space on production and behavior. The various stocking densities were obtained by chaining off stalls or closing headlocks. So, alley space remained constant which may have softened the effect of overstocking that we observed.

Overall, we observed that lying time was reduced by 1.1 hours/day when stocking density increased from 100 to 145%. At the same time, milk yield dropped numerically from 94.6 to 91.3 pounds/day. Interestingly, this 3.3 lb/day difference in milk yield agreed well with a large data set that we had pulled together last year from behavior research here at Miner where found that each one-hour

change in resting time was associated with a 3.5 pound/day change in milk yield. Of course, it could all be coincidence, but I really believe that the relationship between resting and milk yield is real.

As stocking rate increased, standing time in the alleys increased and time spent ruminating while lying decreased. Interestingly, total feeding time was unaffected and averaged about 5 hours/day. What we couldn't measure in our study was rate of eating, and I suspect that this increased as stocking rate increased.

Things became even more interesting when we looked at the differential response of first-lactation versus older cows and lame versus sound cows. As stocking density increased, the difference in milk yield between younger and older cows grew from 6 pounds/day at 100% stocking rate up to nearly 15 pounds/day at higher stocking rates.

As stocking rate increased, the milk yield of lame cows was markedly reduced compared with sound cows. From 100% up to 130% stocking rate, the difference between sound and lame cows in milk yield increased by 26 pounds/day. At 145% stocking rate, the difference between sound and lame cows narrowed because the milk yield of sound cows suffered at this higher degree of stocking. As stocking rate increased to 145%, lying time of lame cows was reduced by one hour and ruminating time was reduced by nearly one hour as well.

With some assumptions and measures from our Institute herd, I made a rough calculation of margin per cow based on the results observed in this study. Even though they are tentative, the calculations point out an interesting trend which I believe would track well with the real-world situation. The margin per cow was similar between 100 and 115% stocking rate (actually it was very slightly greater at 115%), it dropped off substantially at 130%, and really nosedived at 145%. Obviously, this response will differ by farm and the management practices employed. But, these data do agree extremely well with the handful of reported studies that indicate that things become interesting somewhere around 120% stocking rate.

### **Time Budget Evaluator**

We have developed a "Time Budget Evaluator" at Miner Institute as an initial attempt at predicting the impact of management routines and stocking density on the time budget of dairy cows. The targets for resting and eating activity are based on data to-date from larger pen studies as well as more carefully controlled research with smaller group sizes. Although a range exists in measured eating time (3 to 6 h/d) we have chosen 5.5 h/d for this version, although this value can be changed by the user for any given situation. Time spent outside the pen for the milking process and any other activities may also be entered. Similar to eating time, commonly observed times for drinking and standing are incorporated into the spreadsheet, but the user may adjust these values if desired. These inputs allow calculation of time available for resting for a specific situation. This approach is simplistic because it forces the user to either measure, estimate, or accept standard values for eating, drinking, and other activities. As more research is generated, hopefully we will be able to better predict or more easily measure these inputs on-farm.

The spreadsheet also adjusts lying and standing time based on stocking density data presented in Table 3. Because there is very little data, particularly for larger group sizes, the current version of the spreadsheet simply adjusts lying and standing at 120% stocking density. This is an

oversimplification of reality, but there is insufficient data to warrant a more detailed approach. The spreadsheet then subtracts the resting time available for the group from the requirement for resting for both average cows and the highest producing cows in the group (based on data by Matzke, 2003). If the difference is negative (i.e. resting time is deficient), then a predicted milk production loss is predicted using the relationship of one additional hour lying time beyond 7 h/d is associated with 2 lb/cow/d more milk. As previously discussed, this approach simplifies what may well be very complicated impacts on herd health into a single estimate of milk production loss. In field tests, in troubleshooting situations during the past several years, the spreadsheet has proven remarkably accurate at predicting lost milk production on-farm. The final calculation of the spreadsheet simply converts the energy contained in the lost milk yield to the equivalent loss in body weight or condition score. Note that this is simply an equivalent energy calculation, and that there is no published research relating resting time directly to body condition score changes. At the bottom of the spreadsheet, there are calculations of potential losses in milk yield for first-calf heifers and lame cows in mixed groups based on the results of our overcrowding study discussed earlier.

The Excel spreadsheet is available at the Miner Agricultural Institute web site:  
<http://www.whminer.org>.

### **Summary**

Considerably more research is required to develop accurate tools to evaluate management strategies to minimize negative effects on natural behaviors and time budgets. Key information would include measurement of feed intake and feeding behavior for cows that are group-housed in competitive situations. Resting and standing time play a major role in cow health and productivity and effects of management on these two variables must be understood. A simple spreadsheet is presented to assess the time budget for cows on-farm, both as a tool for cautious use and to determine areas requiring further research.

### **Selected References**

- Albright, J. L. 1993. Feeding behavior in dairy cattle. *J. Dairy Sci.* 76:485.
- Bach, A., C. Iglesias, and I. Busto. 2006. A computerized system for monitoring feeding behavior and individual feed intake of dairy cattle in loose-housed conditions. *J. Dairy Sci.* 87:358(Abstr.)
- Batchelder, T. L. 2000. The impact of head gates and overcrowding on production and behavior patterns of lactating dairy cows. In *Dairy Housing and Equipment Systems. Managing and Planning or Profitability*. Natural Resource, Agriculture, and Engineering Service Publ. 129. Camp Hill, PA.
- Boe, K. E., and G Faerevik. 2003. Grouping and social preferences in calves, heifers, and cows. *Appl. Anim. Behav. Sci.* 80:175-190.
- Dado, R. G., and M. S. Allen. 1994. Variation in and relationships among feeding, chewing, and drinking variables for lactating dairy cows. *J. Dairy Sci.* 77:132-144.
- DeVries, T. J., M.A.G. von Keyserlingk, and D. M. Weary. 2004. Effect of feeding space on the inter-cow distance, aggression, and feeding behavior of free-stall housed dairy cows. *J. Dairy Sci.*

87:1432-1438.

DeVries, T. J., M.A.G. von Keyserlingk, and K. A. Beauchemin. 2003. Diurnal feeding pattern of lactating dairy cows. *J. Dairy Sci.* 86:4079-4082.

Grant, R. J. 1999. Management eye on the cow: Taking advantage of cow behavior. Page 39 in Proc. Tri-State Dairy Management Conference. November 10-11, Fort Wayne, IN.

Grant, R. J. 2003. Taking advantage of dairy cow behavior: cost of ignoring time budgets. In Proc. 2003 Cornell Nutr. Conf. For Feed Manufac. October 21-23. Cornell University. Wyndham Syracuse Hotel. Syracuse, NY.

Grant, R. J., and J. L. Albright. 2000. Feeding behaviour. In *Farm Animal Metabolism and Nutrition*. J.P.F. D'Mello, ed. CABI Publishing. New York, NY.

Grant, R. J., and J. L. Albright. 2001. Effect of animal grouping on feeding behavior and intake of dairy cattle. *J. Dairy Sci.* 84:E156-E163.

Kondo, S., and J. F. Hurnik. 1990. Stabilization of social hierarchy in dairy cows. *Appl. Anim. Behav. Sci.* 27:287-297.

Kondo, S., J. Sekine, M. Okubo, and Y. Asahida. 1989. The effect of group size and space allowance on the agonistic and spacing behavior of cattle. *Appl. Anim. Behav. Sci.* 24:127-135.

Matzke, W. C. 2003. Behavior of large groups of lactating dairy cattle housed in a free stall barn. M.S. Thesis. Univ. of Nebraska, Lincoln.

Matzke, W. C., and R. J. Grant. 2002. Behavior of primi- and multiparous lactating dairy cattle in commingled groups. *J. Dairy Sci.* 85:372(Abstr.)

Metz, J.H.M. 1985. The reaction of cows to short-term deprivation of lying. *Appl. Anim. Behav. Sci.* 13:310.

Olofsson, J. 1999. Competition for total mixed diets fed for ad libitum intake using one or four cows per feeding station. *J. Dairy Sci.* 82:69-79.



# Making the Most from Manure

Deanne Meyer  
Livestock Waste Management Specialist  
Department of Animal Science  
One Shields Avenue  
University of California, Davis, CA 95616  
(530) 752-9391  
(530) 752-0175  
dmeyer@ucdavis.edu

Sustainability of any entity requires a balance of resource management while addressing economic viability, environmental impact, and societal needs. No doubt, economic viability is always at the forefront of the decision making process on dairy operations. Over the last few years, environmental compliance and analysis of environmental impact have opened a new language for many in the dairy business. In addition to ever changing regulatory requirements (at the Federal, State, and potentially international levels) producers are faced with ever increasing pressures from an expanding urban society and a global market place. The volatility in production input prices (feed and fuel) combined with sinking prices received for milk and a particularly unstable banking market make most dairy operators (and processors) very nervous. The time-honored practice of adding cows during tough times isn't working for many operators during these difficult times due to over supply of milk in processing plants. Financially, dairy operators are trying to figure out how to cut costs. Yet, various industries and food processors continue to initiate programs and/or respond to consumer groups' concerns in order to inch toward greater sustainability for their supply chain and market outlets.

## **Evaluate your system**

Managing manure to minimize costs and maximize revenue becomes more important when milk supplies are long and milk prices are low. Critically evaluate your existing manure collection, storage, treatment, and utilization systems to determine if and/or where improvements are possible to reduce costs or increase revenues. As always, be sure that any alterations in manure management are acceptable to local and state regulatory agencies when appropriate (if you're in the San Joaquin Valley of California be sure to check with your County permitting agency, Central Valley Regional Water Quality Control Board and the San Joaquin Valley Air Pollution Control District).

***Step 1. Analyze the inputs to the waste stream.*** There are numerous inputs into your liquid/slurry/solid manure waste streams. It's important to identify if simple management changes can reduce costs associated with handling waste (typically by reducing volume). Common sources of input to the waste streams are identified with suggested areas to consider (Table 1).

Table 1. Analysis of waste stream inputs to identify management/infrastructure options to reduce waste stream volume.

Source of input into waste stream	Evaluate this source to reduce contribution to waste stream	Alternative management needs
Water used for milk cooling	Is water reused before entering the waste stream (used for drinking water, udder hygiene, etc.)? Does milk cooling efficiently utilize water?	Modify milk pumping through plate cooler to maximize efficient transfer of heat with minimal water use; modify plumbing system to deliver plate cooler water to water storage system.
Water used for udder hygiene	Can water use be reduced or eliminated?	Increase management of animal housing area; alter bedding use.
Water used to sanitize milking equipment	Can water use be reduced?	
Fresh water used to flush any animal lanes	Can fresh water used for flushing be eliminated?	Re-plumb flush system to recycle liquid manure; modify manure collection to slurry or solid system
Footbaths	Are other products available for use? Would a pre-footbath wash increase effectiveness of footbath (extend footbath duration; reduce number of changes/month).	Install pre-footbath wash. Identify if other products are available and if used monitor foot health closely to be sure new products are acceptable. Potentially switch between products over time.
Rainfall and potential runoff from buildings	Is runoff a significant contributor to liquid storage needs?	Install and maintain gutters to DIVERT roof runoff from liquid storage structure.
Bedding	Are alternative materials available for bedding (potentially ones that have larger particle size, are less damaging to pumps, have lower nutrient composition, are more degradable, are less degradable)? Can less bedding be used?	Modify management of corrals and roofed housing areas to minimize need for bedding; modify bedding material storage area to minimize losses of useful material; modify animal surfaces to minimize need for bedding.
Wasted/spoiled feed	Can feed be managed to reduce waste and spoilage?	Manage wet feeds (especially during extreme weather conditions); Improve management
Earthen material	Does equipment used to collect solid manure capture	Modify solid manure collection equipment/methods

	soil?	(use box scraper instead of tractor bucket)
Feed management	Are diets formulated, mixed, and delivered to get desired production?	Use feed capture system to collect feed data and compare to anticipated ingredient uses; feed supplements only when accounted for in dietary formulations.
other		

**Step 2. Analyze alternative outlets for manure if waste stream is modified.** Most operators are governed by a nutrient management plan of one form or another. It becomes increasingly important to minimize atmospheric losses of nitrogen from manure. This is important since the atmospheric losses reduce the amount of plant available nitrogen in the manure. Nutrient excesses exist when manure nutrients exceed the capacity of the land application area to receive nutrients. Address potential options for alternative composition to existing manure sources (Table 2) and determine if it is feasible to modify current manure collection/treatment practices to yield different compositional outputs (drier, higher N, etc.) and potentially increase income with the new product.

Table 2. Potential modification of existing manure to find if alternative markets exist for manure.

Desired outcome for manure	Potential methods to assist in achieving objective
Increased quantify of manure in solid form	Scrape manure onto surface for air drying (instead of flushing)
Increase N, P, and/or K in manure	Collect as slurry instead of liquid; collect more frequently to reduce N losses;
Modify solid manure characteristics (drier, weed seed ‘free’, or has a reduced pathogen load).	Dewater; heat treat via compost to reduce weed seeds and pathogens; use anaerobic digestion as pathogen reduction treatment.
Specific particle sizes or density.	Select mechanical separation screen to meet requirements; improve separation of sand or earthen components.
If liquid manure has more/less solids.	Use processing centers to concentrate nutrients; reduce water inclusion in stream;

**Step 3. Identify practice(s) or technology(ies) to achieve desired outcomes identified in Step 2 (establish a job description or goal).** Potential investment in technologies may be helpful if the desired modification to manure composition isn’t achieved after alternative management practices are implemented. As identified in previous Western Dairy Management Conferences (2003), it is best to identify the job description before selecting the technology. Once a job description is identified, it is potentially possible to identify one or more technologies or combination of alternative management practices and technologies to achieve the desired outcome. Identification of technologies that have no cross media impacts may be needed for producers in areas where air, water and county regulatory requirements potentially conflict with one another.

There is no perfect technology to manage dairy manure and address both water and air quality concerns. A review of submitted technologies in 2005 by interested stakeholders in California identified that most technology providers were unable to provide data collected by an impartial third party to identify technology effectiveness (See assessment panel). Technologies were categorized as: thermal conversion (combustion, gasification and pyrolysis), solid--liquid separation and filtration, composting, anaerobic digestion, aerators/mixers, nitrification/denitrification processes, covers for lagoons and compost piles, microbials/enzymes/other additives, feed management and miscellaneous. Most vendors merely provided testimonials to market technologies. Technologies have a higher probability of being successful when the job description required is specific and simplistic.

It is easy for a vendor to imply that a technology will resolve all problems associated with manure management. Be sure you **review actual data** from research projects done with the technology ON DAIRY farms. It's critical that the testing process occur on a facility with similar management practices to your facility if you are interested in transferring findings to your operation. Complete Table 3 for the prospective technology and then compare the findings with what you need in a technology. After you review the findings complete your homework and follow-up with calls to the dairy operator where the research was conducted. Ask specific questions to find out if they are satisfied with the technology, if they're still using it, and probe to find out if they paid for it or received it at minimal cost. Point blank ask if they would do it again and if they recommend that others pay full price for it.

**Table 3. Analysis of potential impacts of technology on liquid and solid manure components (identify if each component is reduced, increased, or stays the same if a technology is used).**

Component	Effects on Wastewater	Effects on Manure Solids
Organic Nitrogen		
Ammonia Nitrogen		
Phosphorus		
Dissolves Solids		
Total Dissolved Solids (TDS)		
Forms Nitrate Nitrogen		
Reduces Pathogens		
Stabilize Manure		
Reduce Manure Volume		
Reduce Emissions <sup>1</sup>		

<sup>1</sup> Important to evaluate: reduction of emissions [ammonia, nitrous oxide, volatile (or reactive) organic compounds, methane, hydrogen sulfide, particulate matter, and odors] and production of emissions [carbon monoxide, nitrogen oxides (NOx), nitrous oxide (N<sub>2</sub>O)].

As a reminder, the importance of writing down your job description needs and comparing it to the potential technology is to save you from installing something that will not provide value for you. As an example, the standard anaerobic digestion methodology remains effective to reduce organic fraction in materials. However, it does nothing to salts or P and potentially increases plant available

form of Nitrogen (ammonium form) while reducing the organic fraction of N. If the biogas is burned through a combustion engine to generate electricity you should reduce methane emissions. Depending on your air district and your engine, you may violate emissions of NO<sub>x</sub>, and potentially emit small amounts N<sub>2</sub>O (a very potent greenhouse gas).

### **Cash in on new sources of revenue**

Cap and trade systems for water and air emissions will provide new opportunities for new revenue on dairies. Depending on the location of a dairy, credits for reductions in phosphorus, nitrogen or sediment (erosion) may be available. In other locations, attention to criteria pollutants (particulate matter, NO<sub>x</sub>) or select greenhouse gases (methane, nitrous oxide, carbon monoxide) may have value. Although the United States did not sign the Kiyoto Treaty there are still many opportunities to obtain and market greenhouse gas emissions credits for use by companies in the US or abroad. Additionally, in areas where air quality is poor there may be opportunities to implement management practices/technologies to reduce emissions thereby allowing a business to sell, bank or trade emissions credits. In such airsheds, new or expanding dairy operations must comply with new source review analysis and implement best available control technology and purchase offsets. In California, "the state regulation identifies general requirements and criteria that local air districts must meet in certifying, calculating, banking, and using emission credits. The state regulation ensures that emission credits represent real reductions in air pollutants, that reductions are surplus to any reductions already required, and that reductions are not "double counted" or credited more than once".

***Emissions Reduction Credits.*** An existing emissions source can implement management/technology practices to reduce these emissions. Another emissions source interested in increasing emissions is not able to do so absent the opportunity to offset these emissions. The sum of the reduction and increase must not exceed zero. . One of the challenges is to validate the actual emissions reductions. Reductions must be real, quantifiable, and permanent. Reductions must be proven to have occurred. This requires a third party analysis to confirm reductions and must be completed per the regulatory and/or emission credit agency specifications. Accepted methodology must be available and employed when measuring emission reductions. Reductions are intended to be permanent. NOTE: It is probably that offsets would need to be purchases if in the future one would no longer generate the reductions.

The more commonly identified compounds for emission credits are criteria pollutants regulated through the Clean Air Act (NO<sub>x</sub>, ROC, SO<sub>x</sub>, and CO). Alternatively, one may seek to participate in carbon credits. As part of many local and regional Climate Action Initiatives there will be great pressure to reduce carbon footprint from dairy operations. As an example, the Western Regional Climate Action Initiative (including California, Utah, New Mexico, Arizona Washington, Oregon, and British Columbia) aims to reduce aggregate emissions 15 percent below 2005 levels by 2020. In California, AB32 is well on its way to inventory greenhouse gas emissions and identify methodology to implement emission reductions.

For almost all emissions, one is going to hire a consulting firm familiar with completing the required documentation and working on your behalf to receive high returns in the market for your reductions. Be sure you do your homework before hiring your consulting firm. Be sure they know how to get through your specific emission source, understand (and are able to document) emission reductions,

are familiar with County, Regional and State regulatory obligations and emission credit options and have a solid track record.

**Renewable energy credits.** After last summer's incredibly volatile fuel prices it is a given there will be more incentives available for Federal and potentially State renewable energy credits. These programs are associated with "green" or "environmentally friendly" practices. They produce two products. The first is a tradable renewable credit, the second is electricity. Again, consulting firms are available to identify market opportunities, identify useful technologies, and assist in obtaining low cost financing. Reasons to invest in "green" power include improving image, satisfy regulatory need, or control costs of energy use. The potential investment now in reducing energy costs in the future may be a viable option. In some areas this will include generating energy from solar, wind or methane. Depending on the technology installed, market demand of local electric supplier, and potential payments for electricity it may or may not be more desirable to sell electricity off-farm or utilize it on-farm.

**Addressing Sustainability.** During the summer of 2008 the dairy industry held its first Sustainability Summit and developed an action plan committed to reducing greenhouse gases and increasing business opportunities across the value chain. Defining and marketing sustainability will be a necessary challenge for all of dairy production. The idea is to reduce fluid milk's carbon footprint while increasing business value from farm to consumer. [Carbon footprint is a measurement of the total CO<sub>2</sub> equivalents produced—in the case of producing milk it includes all CO<sub>2</sub> equivalents produced from manufacture of fertilizer, crop production/harvest/transportation, and animal husbandry.] More than 250 leaders representing producers, processors, non-governmental organizations, university researchers and government agencies held in Rogers, Ark., June 16 to June 19, 2008. The plan focuses on operational efficiencies and innovations to reduce greenhouse gas emissions while ensuring financial viability and industry growth.

"Decision makers from across the dairy value chain are working together to commit to concrete, innovative solutions. This will ensure an economically, environmentally and socially sustainable industry" said Thomas Gallagher, chief executive officer of Dairy Management Inc. (DMI). "In an era of record high energy prices and a changing global climate, we must do more. It makes economic sense to find ways to conserve energy and reduce production costs, while recognizing that a growing number of consumers care deeply about the health and environmental impact of the products they buy" said Jerry Kozak, National Milk Producer Federation's chief executive officer. Leading the initiative along with DMI are NMPF representing dairy cooperatives, and the International Dairy Foods Association representing processors and manufacturers.

Summit attendees recommended a number of actions, including to:

- Reduce energy use in the milk supply chain by developing technologies for next generation milk processing on the farm and in the plant.
- Establish a mechanism to optimize returns to the dairy industry from a carbon credit trading system that encourages the reduction of greenhouse gas emissions.
- Reduce carbon emissions and increase energy efficiency for dairy farmers and processors through financially viable best management practices and tools that calculate individual farm energy and alternative energy opportunities.
- Supply green power to communities by expanding the use of methane digesters.

- Stimulate development of low-cost, low-carbon, consumer-acceptable packaging.
- Reduce cooling costs and emissions associated with refrigeration by expanding economically feasible, environmentally responsible and consumer-accepted dairy products.

Over the next few years there will be a tremendous amount of information appearing in business journals and magazines and in popular press literature. Large variations in results will occur. Life Cycle Analysis methodology is used to address carbon emissions values. Already results from studies identify different emissions values depending on the boundaries established within each study. When one study focuses on inventories managed only by farmers the results will be different when compared to a study that also includes growth of all feed ingredients, transportation to farm and farm to market, and processing activities. It is very important that the dairy industry be engaged in the life cycle analyses being conducted.

### References:

Ball, J. 2008. Six Products, Six Carbon Footprints Everybody's talking.  
<http://online.wsj.com/article/SB122304950601802565.html>. October 6, 2008

California Air Resources Board. 2005. Annual Report on State Regulation on Emissions Trading Methodology (H&SC Section 39607.5) May. <http://www.arb.ca.gov/research/apr/reports/l3039.pdf>

Meyer, D., J. Harner, W. Powers, E. Tooman. 2003. Manure technologies for today and tomorrow. Proceedings of the 6<sup>th</sup> Western Dairy Management Conference; March 12-14, 2003, Reno, NV. Available at:  
<http://www.wdmc.org/2003/Manure%20Technologies%20for%20Today%20and%20Tomorrow.pdf>

National Milk Producer Federation. 2008. Dairy Industry Commits to Reducing Greenhouse Gases, Increasing Business Opportunities Across Value Chain. June 25.  
[http://www.nmpf.org/latest\\_news/press\\_releases/carbon\\_footprint062508](http://www.nmpf.org/latest_news/press_releases/carbon_footprint062508)

San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel. 2005. An Assessment of Technologies for Management and Treatment of Dairy Manure in California's San Joaquin Valley. Available at:  
<http://www.arb.ca.gov/ag/caf/dairypnl/dmtfaprprt.pdf>

Western States Climate Initiative. <http://www.westernclimateinitiative.org/>



# In the Thermoneutral Zone: Potential Benefits of LPCV Buildings

Joseph P. Harner  
Extension Engineer, Livestock & Grain Systems  
Kansas State University  
Bio & Ag Engineering  
Seaton Hall 147  
Manhattan, KS 66506-2917  
Office - 785-532-2930  
Fax - 785-532-6944

J.F. Smith,  
B. J. Bradford,  
M.W. Overton,  
K.C. Dhuyvetter

## Introduction

Low profile cross ventilated (LPCV) freestall buildings provide a temperate environment that ranges within a dairy cow's thermoneutral zone even during summer and winter months. LPCV buildings typically maintain an air temperature 8-15°F cooler than ambient during the summer, but the relative humidity is often 75% or greater due to evaporative cooling and moisture generated by cows. In the winter the interior of an LPCV building is 10-30°F warmer than outside air temperatures.

The ability to control a cow's environment increases milk production, improves feed efficiency, raises income over feed cost, strengthens reproductive performance, allows for controlled lighting, reduces lameness, and lessens fly-control costs. The benefits of LPCV buildings may be examined by reviewing scientific literature and understanding improvements that are possible when an environment complements a cow's thermoneutral zone.

## Environmental Impact on Nutrient Requirements and Efficiency

Dairy cows that are housed in an environment outside their thermoneutral zone alter their behavior and physiology in order to adapt. Adaptations are necessary to maintain a stable core body temperature, but nutrient utilization and profitability are negatively affected.

The upper critical temperature, or upper limit of the thermoneutral zone, for lactating dairy cattle is approximately 70-80°F for maximum nutritional benefits (NRC, 1981). When temperatures exceed the recommended range, cows combat heat stress by decreasing feed intake (Holter et al., 1997), sweating, and panting. These mechanisms increase the cows' energy costs, resulting in up to 35% more feed necessary for maintenance (NRC, 1981). When dry matter intake decreases during heat stress, milk production also decreases. A dairy cow in a 100°F environment decreases milk production by 50% or more as compared to thermoneutral conditions (Collier, 1985).

Relatively little research has been done on the effect of cold stress on lactating dairy cattle. The high metabolic rate of dairy cows makes them susceptible to heat stress in U.S. climates, so, as a result, the lower critical temperature of lactating dairy cattle is not well established. Estimates range from

as high as 50°F (NRC, 1981) to as low at -100°F (NRC, 2001). Regardless, evidence shows that the performance of lactating cows decreases at temperatures below 20°F (NRC, 1981).

One clear effect of cold stress is increased feed intake. While greater feed intake often results in greater milk production, cold-induced feed intake is caused by an increase in the rate of digesta passage through the gastrointestinal tract. An increased passage rate limits digestion time and results in less digestion as temperatures drop (NRC, 2001). Cows also maintain body temperature in cold environments by using nutrients for shivering or metabolic uncoupling, both of which increase maintenance energy costs. These two mechanisms decrease milk production by more than 20% in extreme cold stress. However, even when cold stress does not negatively impact productivity, decreased feed efficiency hurts dairy profitability.

Smith et al (2008) assessed the effects of environmental stress on feed efficiency and profitability. He used a model which incorporated the temperature effects on dry matter intake, diet digestibility, maintenance requirements, and milk production. Figure 1 shows the expected responses of a cow producing 80 pounds of milk per day in a thermoneutral environment. The model was altered to assess responses to cold stress if milk production is not decreased. In this situation, the decrease in diet digestibility results in an 8% decrease in income over feed cost as temperatures drop to -10°F. With these research results, cost benefits could be estimated for environmental control of LPCV facilities.

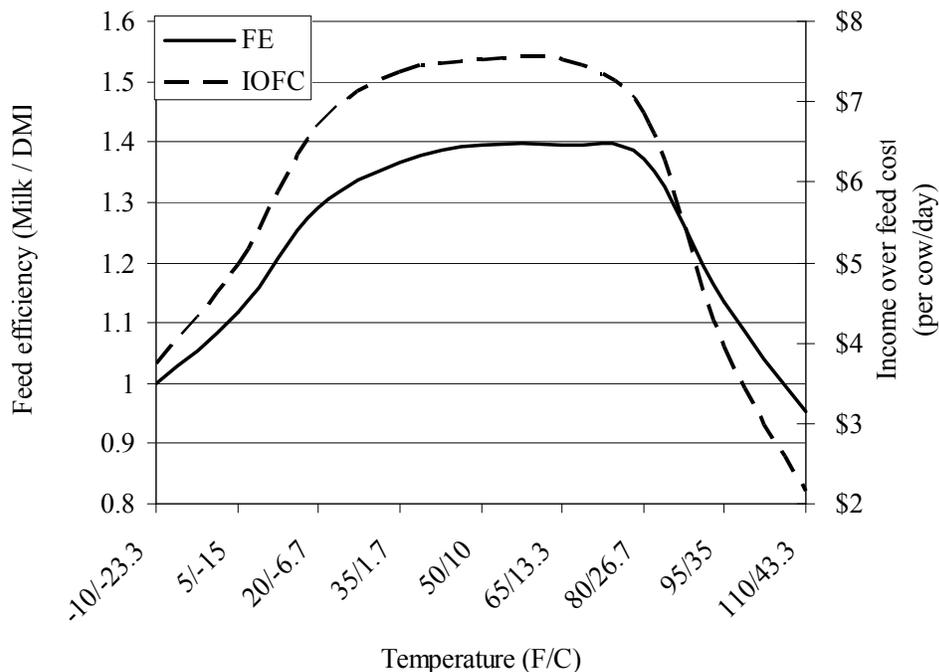


Figure 1: Responses to Environmental Stress (thermoneutral production of 80 lbs/day, MR Cost of \$0.12/lb dry matter, and milk value of \$18/cwt)

## Environmental Impact on Reproduction

Even though cold stress has little effect on reproduction, heat stress reduces libido, fertility, and embryonic survival in dairy cattle. Environmental conditions above a dairy cow's thermoneutral zone decrease the ability to dissipate heat and result in an increased core body temperature. The elevated body temperatures negatively impact reproduction for both the female and the male.

The impact of heat stress can be categorized by the effects of acute heat stress (short-term increases in body temperature above 103°F) or chronic heat stress (the cumulative effects of prolonged exposure to heat throughout the summer). In acute heat stress, even short-term rises in body temperature result in a 25-40% drop in conception rate. An increase of 0.9°F in body temperature causes a decline in conception rate of 13% (Gwazdauskas et al.). As milk production and feed intake increase, a greater internal heat load is produced and the impact of heat stress on reproduction is dramatic (al-Katanani et al., 1999).

Whether the decline in pregnancy rates is voluntary or not, a fewer number of pregnant cows creates holes in the calving patterns. In the fall an increased number of cows often become pregnant and, consequently, place additional pressures on the transition facilities nine months later when an above-average group of cows must move through the close-up and fresh cow pens. Overcrowding these facilities leads to increases in post-calving health issues, decreased milk production, and impaired future reproduction.

### Creating a Thermoneutral Zone Housing Environment

Changing the environment to reflect the thermoneutral zone of a dairy cow minimizes the impact of seasonal changes on milk production, reproduction, feed efficiency and income over feed cost. Evaporative cooling is often used to cool LPCV buildings, and Harner and Smith (2008) discuss specific design details of the buildings when this cooling method is utilized. The ability to lower air temperature through evaporative cooling is dependent upon ambient temperature and relative humidity. As relative humidity increases, the cooling potential decreases, as shown in Figure 2. Cooling potential is the maximum temperature drop possible, assuming the evaporative cooling system is 100% efficient. The cooling potential is greater as air temperature increases and relative humidity decreases. Evaporative cooling systems perform better as the humidity decreases below 50 percent.

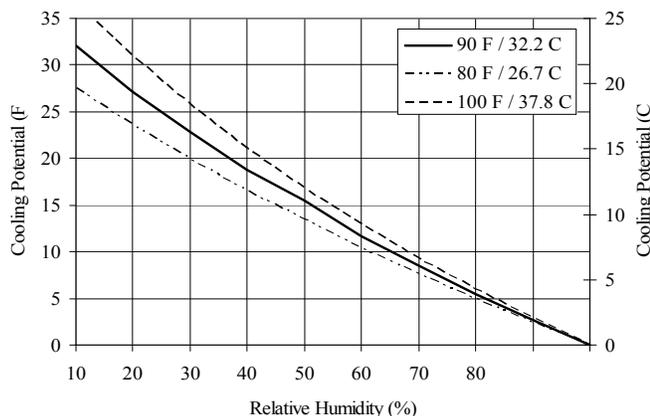


Figure 2: Impact of Relative Humidity and Temperature on Cooling Potential with an Evaporative Cooling System

The cooling potential is a function of the air's ability to absorb moisture. Additional moisture in the air decreases the air temperature and increases humidity. Theoretically, the lowest possible air temperature occurs when the air is at 100% humidity, or saturation. Most designers assume the air temperature exiting an evaporative cooling system is reached when the air has absorbed 75% of the moisture possible between inlet conditions and saturation. Since the outdoor air temperature constantly changes, the exhaust temperature from an evaporative cooling system also changes.

LPCV buildings range in width from 200-500 feet, and the number of rows or freestalls vary from 8-24, depending on the building width. The targeted air exchange rate through the buildings is 120 seconds or less, but buildings wider than 300 feet have exchange rates of 180-240 seconds\

Different management strategies for environmental control are used during cold weather. The first mode decreases the air exchange rate by turning off fans in order to prevent frozen manure on the alleys. This strategy prevents potential lameness and injury problems but leads to a potential increase in ammonia and moisture levels inside the building. The second management strategy utilizes a controller to operate fans along the inlet side of the building. The disadvantage of this mode is that as the outdoor air temperature declines, the number of operating fans remains constant. As a result, cold temperatures are maintained inside the building, manure freezes in alleys near the inlet, and employees are exposed to very cold temperatures. Research indicates that an 8-minute air exchange is the recommended maximum air exchange rate.

Though the interior of a LPCV building closely resembles a naturally ventilated freestall (Harner and Smith, 2008), LPCV buildings incorporate baffles to divert air flow into the stall area. Depending on the number of baffles, air speed in the stall area is increased from 2-3 miles per hour (mph) to 6-8 mph during the summer months. Dairies that utilize baffles observe better lay-down rates of cows and report a corresponding increase in milk production.

### **Results of Environmental Studies in LPCV Buildings**

Table 1 summarizes the temperature rise across LPCV buildings in the upper Midwest from July 17 to August 16, 2007. A temperature increase of 0.85 °F per 100 feet of building width was observed. Since the humidity in the building was high due to the evaporative cooling system, approximately a 1 unit increase in the temperature humidity index (THI) existed per 100 feet of building width.

Table 2 compares the average, maximum and minimum ambient temperatures with the interior conditions of a 400-foot wide LPCV building in Iowa. The average ambient temperature and relative humidity from July 17 to August 16, 2007, was 77°F and 77%, respectively. The average temperature inside the LPCV building was approximately 3°F cooler than ambient, but the maximum temperature was 85°F as compared to the outside temperature of 96°F. The ambient temperatures were 77°F or greater for over 50% of the study. However, when measured near the exhaust fans of the LPCV building, the ambient temperature was greater than 77°F only 28% of the time. Also, the ambient temperatures were less than 68°F only 7% of the time, as compared to 12% inside the LPCV building. However, during the night, the indoor temperatures increased because the evaporative cooling pad was turned off to allow the pad to dry and prolong pad usage.

Table 1: Average Temperature Rise Between Baffles and Per Foot of Building Width

Dairy ID	Nominal Building Width ft	Average Temperature (°F) Rise/Foot of Building Width*
# 1	400	0.0085 °F/ft
# 2	400	0.0077 °F/ft
# 3	520	0.0110 °F/ft
# 4	300	0.0095 °F/ft
# 5	250	0.0057°F/ft
Average		0.0085 °F/ft

\*Average values per dairy are based on 2,880 hourly average measurements including nighttime data.

Table 2: Comparison of Ambient and Interior Temperatures

	Ambient	Inlet Baffle	Middle Baffle	Exhaust Baffle
Average Temperature (°F)	77	73	74	74
Maximum Temperature (°F)	96	85	83	85
Minimum Temperature (°F)	58	58	59	58
Percent of Hours at 77 °F or above	52	21	24	28
Percent of Hours Between 68 to 77 °F	41	67	66	60
Percent of Hours Below 68 °F	7	12	10	12

Figure 3 illustrates the average ambient, inlet and exhaust temperatures in a 400-foot wide LPCV building in Iowa from July 17 to August 16, 2008.

Temperature data was also logged during the winter of 2008. The data was averaged by hour and baffle location from January 18 to February 17, 2008, as shown in Figure 4. The ambient temperature during the winter period averaged 20 °F colder than barn conditions. Figure 4 shows a rapid warming of the air between the inlet and first baffle in two LPCV facilities, and the air continued to warm until exhausted from the building. Figure 4 also shows the exhaust air temperature as a function of inlet (outdoor) air temperature. As the outdoor air temperature decreased, the variability in exhaust temperature increased. The exhaust air temperature was 25-45°F when the inlet air temperature was -5°F. The variability is attributed to a difference in air exchange rates because air temperature is lower at the exhaust as the air exchange rate increases

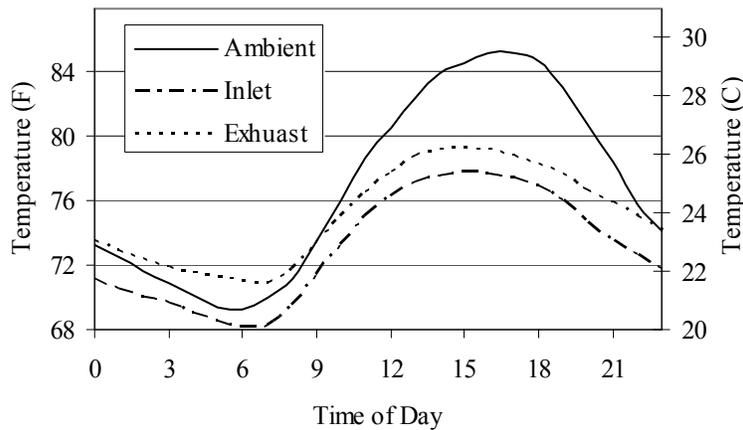


Figure 3: Comparison of Ambient, Inlet and Exhaust Temperatures

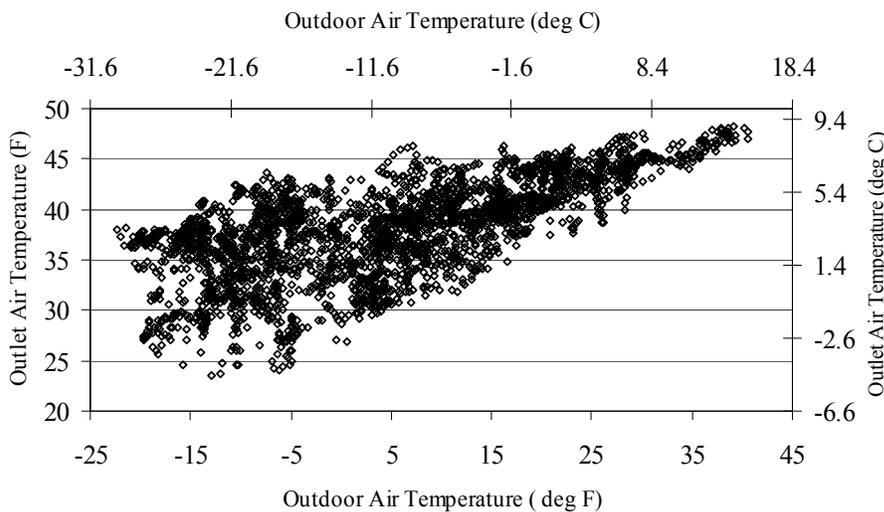


Figure 4: Relationship Between Outdoor Air Temperatures and Outlet (Exhaust) Air Temperatures in a 400-foot wide LPCV building

Figure 5 shows a correlation between the outdoor air temperature and the temperature rise across an LPCV building in Minnesota during the winter of 2008. Temperature rise is defined as the difference between the exhaust and outdoor air temperature. Less variability exists in the temperature rises above 20°F since there are more consistent strategies in fan operation and less concern about freezing alleys.

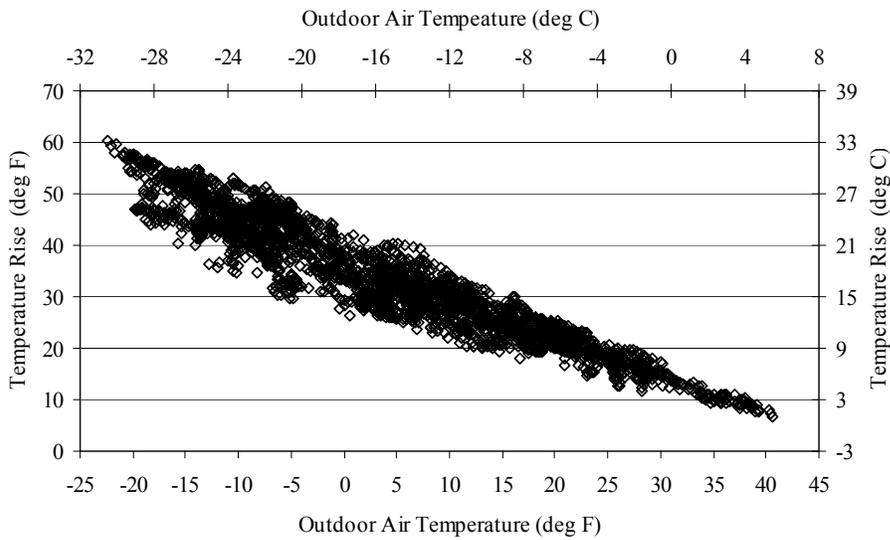


Figure 5: Outdoor Air Temperatures and Temperature Rise in a 500-foot wide building

Figure 6 illustrates the average hourly temperatures from January 18 to February 17, 2008, inside two 400-foot wide LPCV buildings in the upper Midwest. The difference in temperature rise from the inlet to the exhaust is explained by different stocking densities and air exchange rates.

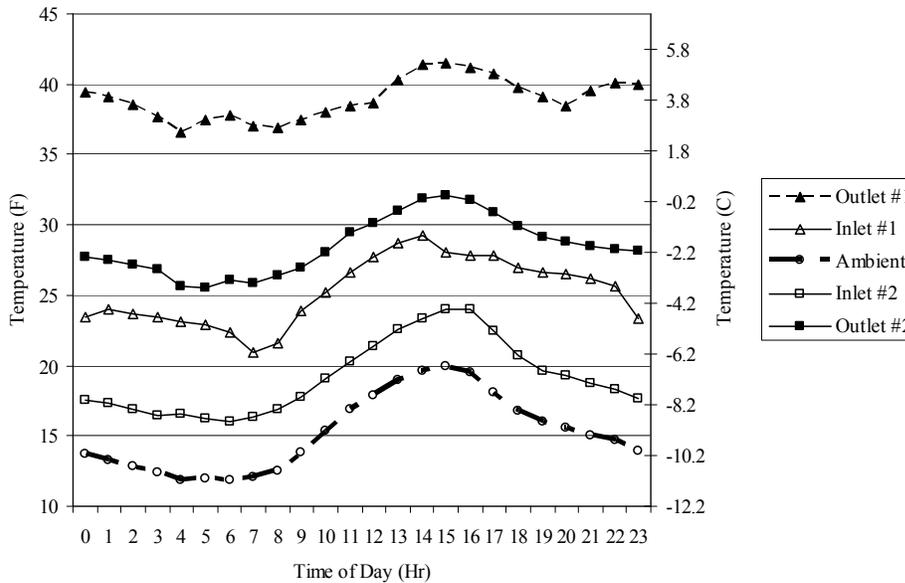


Figure 6: Summaries of Temperatures in LPCV Buildings

### Impact of Geographical Location

Table 3 provides annual hours when the ambient temperatures is within  $\pm 5^\circ\text{F}$  increments for various dairy locations in the United States. The data was obtained from a military base near the selected locations. Dairy cows experience more hours of ambient temperatures below their lower

thermoneutral zone limit (20°F) when housed on dairies in northern states and more hours of ambient temperatures above their upper thermoneutral zone limit (70°F) when housed on dairies in southern states.

Figure 7 shows that ambient temperatures are within the thermoneutral zone 65-78% of the time for a majority of major dairy locations in the United States. The exceptions are Gainesville, FL and Phoenix, AZ where the ambient temperatures are within the thermoneutral zone only 50% of the year. Yearly ambient conditions result cows being exposed to heat stress, cold stress or both 25% of the year.

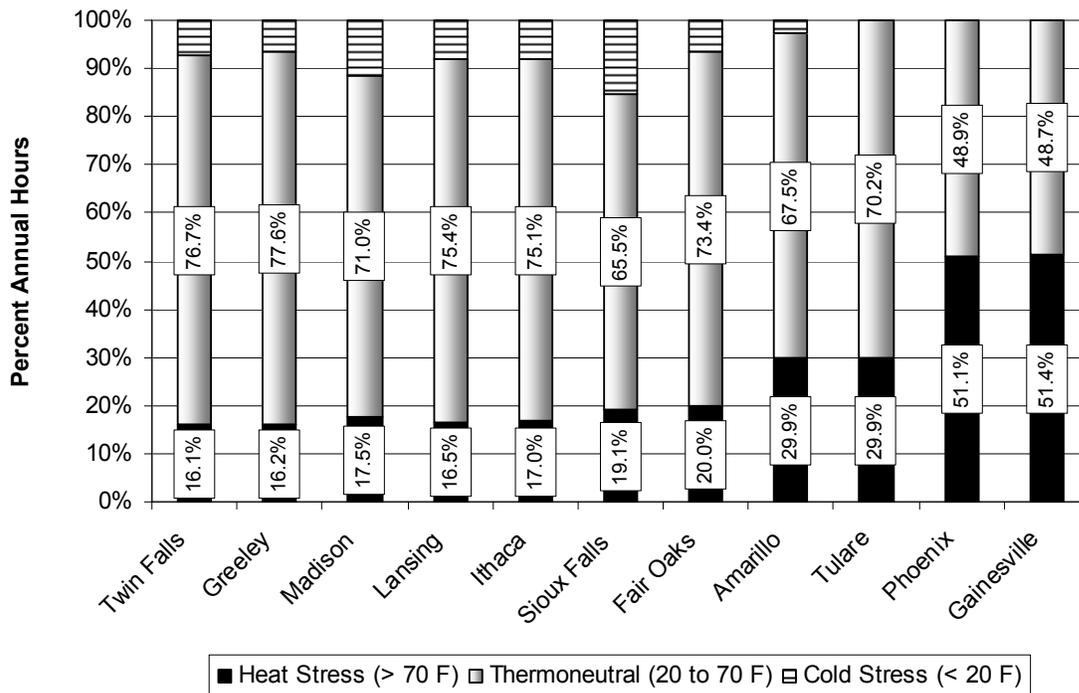


Figure 7: Percentage of Annual Ambient Hours in the Thermoneutral Zone of Dairy Cows

Figure 8 shows the potential benefits of LPCV buildings. The housing environment may be efficiently maintained within the cow's thermoneutral zone 85-93% of the time. The evaluation is based on temperature only so, with evaporative cooling and low relative humidity in Phoenix, AZ, the percentage of hours within the thermoneutral zone could be greater than 65 percent. Research shows that, regardless of location, LPCV buildings increased the annual number of hours the housing environment measured within a cow's thermoneutral zone by 17 percent

Table 3: Annual Hours in 5°F Increments for Dairy Locations in the United States

	Tulare, CA (Merced, CA)	Twin Falls, ID (Pocatello, ID)	Greely, CO (Denver, CO)	Sioux Falls, SD (Sioux Falls, SD)	Madison, WI (Madison, WI)	Lansing, MI (Lansing, MI)	Fair Oaks, IN (South Bend, IN)	Ithaca, NY (Syracuse, NY)	Gainesville, FL (Jacksonville, FL)	Amarillo, TX (Amarillo, TX)	Phoenix, AZ (Glendale, AZ)
>100	62			2						9	517
95-99	159	21	7	20	6	2	5	3	38	88	463
90-94	287	99	71	92	42	27	51	28	276	258	592
85-89	364	206	174	182	137	115	159	120	579	385	709
80-84	457	285	291	310	287	261	324	265	810	485	753
75-79	581	352	384	463	451	411	504	441	1229	602	730
70-74	707	443	494	598	605	626	707	628	1563	790	710
65-69	804	518	618	661	689	731	761	731	987	852	759
60-64	965	582	794	664	726	734	718	718	867	766	801
55-59	1100	653	776	593	639	675	610	709	702	670	801
50-54	1098	683	739	532	548	601	588	666	633	667	725
45-49	902	705	729	508	523	578	562	628	440	634	573
40-44	681	776	752	504	510	574	585	633	318	615	378
35-39	397	852	724	572	631	701	711	723	187	592	179
30-34	159	885	704	668	827	859	860	812	94	533	57
25-29	32	637	555	563	663	687	615	554	28	369	7
20-24	1	419	394	465	458	452	409	400	6	205	1
15-19		250	243	394	314	314	241	292		127	
10-14		164	137	277	247	190	164	200		58	
5-9		105	84	238	179	115	87	113		28	
< 5		115	98	442	276	102	95	90		15	

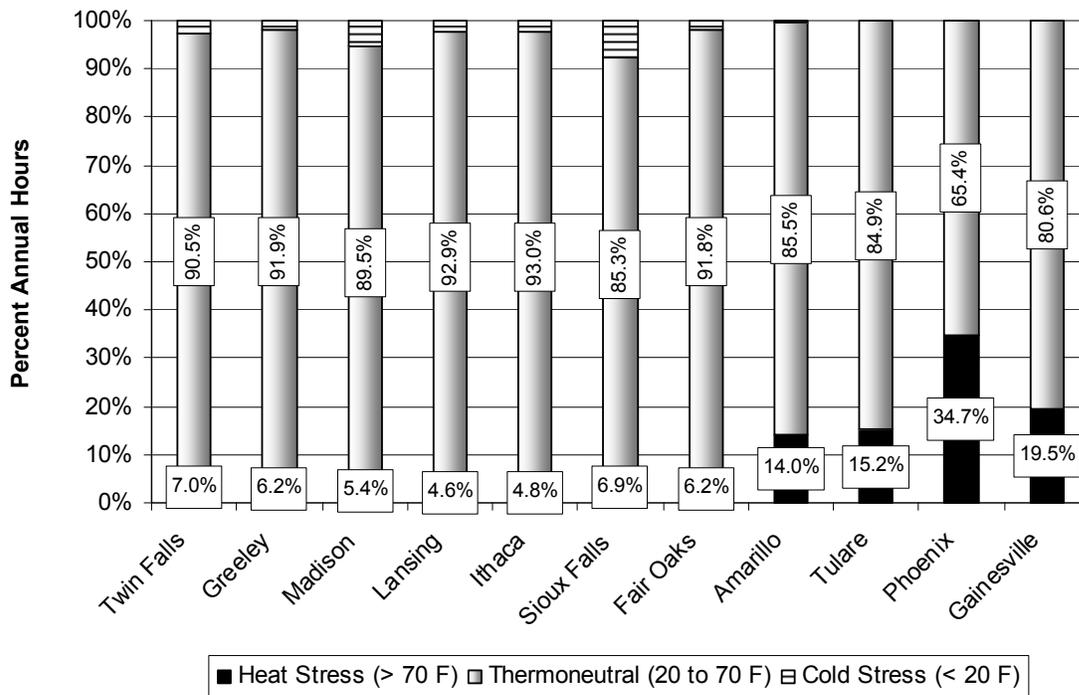


Figure 8: Impact of LPCV Freestall Housing on Percentage of Annual Hours in the Thermoneutral Zone

Table 4 compares the weather conditions from February 1-15, 2008, at different locations. Except for Sioux Falls, SD, the ambient temperature was above the lower limit of the thermoneutral zone 65-75% of the study for dairies in the northern states. Dairy cows in the southern states did not experience cold stress during this period.

Table 5 compares the weather conditions from August 1-15, 2008, at different locations. Except for Ithaca, NY, the ambient temperature exceeded the upper limit of the thermoneutral zone at least 65% of the time for dairies in the northern states.

Table 4: Hours When Ambient Temperature Was Less than Lower Limit (20°F) of Thermoneutral Zone

Dairy Locations Arranged Based on Coldest to Warmest Average Temperature (F) From Feb 1-15, 2008										
	Sioux Falls SD	Ithaca, NY	Madison, WI	Lansing, MI	Fair Oaks, IN	Twin Falls, ID	Amarillo, TX	Tulare, CA	Phoenix, AZ	Gainesville, FL
Ambient Temperatures (F)										
Average (F)	13.3	27.1	19.7	23.7	26.1	31.8	42.3	47.7	53.4	60.1
Maximum (F)	30	50	35	45	49	48	69	68	76	83
Minimum (F)	-9	1	-9	-3	0	14	17	30	35	29
Hours within Temperature Range										
Temperature Range										
>= 20 F	105	277	220	241	248	335	331	335	335	335
10 to 20 F	109	29	42	45	55	0	4	0	0	0
<10 F	122	30	73	49	32	0	0	0	0	0
Percentage of Hours within Temperature Range										
Temperature Range										
>= 20 F	31.3	82.5	65.7	72.0	74.1	100	98.8	100	100	100
10-20 F	32.4	8.6	12.5	13.4	16.4	0	1.2	0	0	0
<10 F	36.3	8.9	21.8	14.6	9.6	0	0	0	0	0

Table 5: Hours When Temperature Exceeded Upper Limit (70°F) of Thermoneutral Zone

Dairy Locations Arranged Based on Coldest to Warmest Average Temperature (F) From Feb 1-15, 2008										
	Sioux Falls SD	Ithaca, NY	Madison, WI	Lansing, MI	Fair Oaks, IN	Twin Falls, ID	Amarillo, TX	Tulare, CA	Phoenix, AZ	Gainesville, FL
Ambient Temperatures (F)										
Average (F)	73.1	65.1	69.5	68.3	72.3	75.4	77.4	81.3	94.5	80.1
Maximum (F)	91	81	87	86	91	96	94	104	112	94
Minimum (F)	57	49	51	49	56	57	58	58	77	70
Hours within Temperature Range										
Temperature Range										
>= 70F	213	97	177	158	215	216	249	266	336	336
<70 F	123	239	159	178	121	120	87	70	0	0
Percentage of Hours within Temperature Range										
Temperature Range										
>= 70 F	63.4	28.9	52.7	47.0	64.0	64.3	74.1	79.2	100	100
<70 F	36.6	71.1	47.3	53.0	36.0	35.7	25.9	20.8	0	0

The THI of the ambient conditions is compared in Table 6. The THI exceeded 70 over a range of 12-100% from August 1-15, 2008, depending on geographical location. Assuming the evaporative cooling system was 100% efficient, the percentage of time at most of the locations was less than 5%, with the exception of Fair Oaks, IN and Gainesville, FL which experienced high relative humidity.

Table 6: Hours When THI Equalled 70 or Greater

	Dairy Locations - August 1 – 15, 2008									
	Sioux Falls SD	Ithaca, NY	Madison, WI	Lansing, MI	Fair Oaks, IN	Twin Falls, ID	Amarillo, TX	Tulare, CA	Phoenix, AZ	Gainesville, FL
	Ambient Temperature Humidity Index									
Average THI	70.3	63.8	67.3	65.9	69.4	68.4	71.5	72.3	80.7	76.9
Maximum THI	83.6	75.6	78.7	78.4	83	79.5	79.1	83.8	85.6	84.1
Minimum THI	57	49	51.4	49.5	56	57.3	58	58	73.6	69.1
	Hours when THI => 70 (336 maximum number of hours)									
Ambient Conditions	192	41	132	114	178	137	208	207	336	328
Benefit of LPCV assuming 100 % efficiency	22	1	18	3	54	0	0	0	4	285
	Percentage of Hours THI => 70(336 maximum number of hours)									
Ambient Conditions	57.1	12.2	39.2	33.9	53.0	40.7	61.9	61.6	100	97.6
Benefit of LPCV assuming 100 % efficiency	6.5	0.3	5.4	0.9	16.1	0	0	0	1.2	84.8

### Summary

LPCV facilities are able to minimize fluctuations in core body temperature by providing an environment which closely resembles a cow’s thermoneutral zone.

- Heat stress and cold stress significantly decrease income over feed cost. Limiting environmental stress throughout the year increases feed efficiency.
- Temperatures inside a LPCV building with evaporative cooling are 8-15°F cooler than ambient temperatures during afternoon hours.
- Temperatures inside a LPCV building during the winter months are 15-30°F warmer than ambient temperatures, depending on the air exchange rate.

- Improving a cow's environment greatly reduces the impact of heat stress on present and future milk production.

## References

- Al-Katanani, Yaser M., D.W. Webb, and P.J. Hansen. 1999. "Factors Affecting Seasonal Variation in 90-Day Nonreturn Rate to First Service in Lactating Holstein Cows in a Hot Climate." *Journal of Dairy Science* 82:2611-2616.
- Armstrong, D.V. and P.E. Hillman. 1998. Effect of Cold Stress on Dairy Cow Performance. Colorado Nutrition Conference. Jan 1998.
- Berry, I.L., M.D. Shanklin, and H.D. Johnson. 1964. Dairy Shelter Design Based on Milk Production Decline as Affected by Temperature and Humidity. Transaction of ASAE; 7(3) pp. 329-331.
- Bouraqui, R., M. Lahmar, A. Majdoub, M. Djemali, and R. Belyea. 2002. The Relationship of Temperature-Humidity Index with Milk Production of Dairy Cows in a Mediterranean Climate. *Anim. Res.* 51(2002) 479-491.
- Collier, R. J. 1985. "Nutritional, metabolic, and environmental aspects of lactation." B. L. Larson, ed. Iowa State University Press, Ames, IA.
- Harner, J.P. and J.F. Smith. (editors). 2008. Proceedings of the Dairy Housing of the Future: Opportunitites with Low Profile Cross Ventilated Housing. Sept 2008. Sioux Falls, ID.
- Hillman, P.E., C.N. Lee and S.T. Willard. (2005). Thermoregulatory Responses Associated with Lying and Standing in Heat-Stressed Dairy Cows. Transaction of ASAE. 48(2):795-801
- Holter, J. B., J. W. West, and M. L. McGilliard. 1997. "Predicting ad libitum dry matter intake and yield of Holstein cows." *J. Dairy Sci.* 80(9):2188-2199.
- NRC. 1981. "Effect of Environment on Nutrient Requirements of Domestic Animals." Natl. Acad. Sci., Washington, DC.
- NRC. 2001. "Nutrient Requirements of Dairy Cattle." 7th rev. ed. *National Research Council*. Natl. Acad. Sci., Washington, DC.
- Overton, M.W. 2006. "Cash Flows of Instituting Reproductive Programs: Cost vs. Reward." 39<sup>th</sup> Annual Convention of the American Association of Bovine Practitioners, 2006.
- Smith, J.F. and J.P. Harner. 2008. Low-Profile Cross-Ventilated Freestall Facilities, Another Option for Cow Housing, Proceedings of the 2008 Tri-State Northwest Dairy Shortcourse. Boise, ID. Jan, 2008. pp 81-98.

Smith, J.F., J.P. Harner, B.J. Bradford and M. Overton. 2008. Opportunities with Low-Profile Cross-Ventilated Freestall Facilities. Proceedings of the Dairy Housing of the Future: Opportunites with Low Profile Cross Ventilated Housing. Sept 2008. Sioux Falls, ID.



# Improving the Welfare of Dairy Cattle: Implications of Freestall Housing on Behavior and Health

Marina von Keyserlingk and Dan Weary

Animal Welfare Program, University of British Columbia, 2357 Mall, Vancouver, BC, Canada, V6T 1Z4  
Email: marina.vonkeyserlingk@ubc.ca Tel: 604 822 4989, Fax: 604 822 2184

## Take Home Messages

- 1) The design and management of the feeding area important. High stocking densities at the feed bunk increase aggressive competition and keep subordinate cows away from feed. Cows who consume less feed are at greater risk for disease.
- 2) Physical barrier between cows, including head lockers and feed stalls, can help reduce this competition and increase feeding time.
- 3) Cows like softer surfaces, for both lying down and for standing upon. Deep-bedded stalls work well for cow comfort, but require maintenance.
- 4) When it comes to the physical structures used to build freestalls, less is more – the hardware we place in the stall is for our benefit and not the cows. The more restrictive we design stalls the less attractive they become for the cow.
- 5) Access to a dry, comfortable standing area reduces the risk of lameness. A rest period on pasture helps lame cows recover.

## Introduction

Poorly designed and managed facilities cause injuries and increase the risk of health problems such as lameness. Producers spend millions of dollars building and renovating their barns with the aim of providing a comfortable environment for their dairy cows, but there has been little work done to scientifically assess cow comfort on commercial farms and to allow producers to evaluate their own facilities. This paper provides an overview of key research findings from our group at The University of British Columbia. This gives us the chance to highlight our own research and what we think are some particularly interesting and promising approaches focusing on the implications of freestall housing on behavior and health for intensively managed dairy cattle.

## Cow Comfort

The issue of cow comfort has received considerable interest within the dairy industry, with the bulk of research having focused on the design of free-stalls and the effect of stall design upon stall occupancy and the time spent resting. This research-based knowledge on stall design is now beginning to be implemented in the design of new barns (Le Blanc et al., 2006).

Most research on stall design for cattle has concentrated on two aspects: the surface cows lie down upon, and how the free stall is configured. Cows clearly prefer softer lying surfaces with more bedding, and spend more time lying down in well-bedded dry stalls (Haley et al., 2001, Manninen et al., 2002, Tucker and Weary, 2004; Fregonesi et al. 2007). However, the lying surface can also affect udder health. Use of organic bedding material can increase the risk of some types of mastitis and many studies have now shown the advantages to cows of using sand or other inorganic bedding as a way of reducing the growth of bacteria associated with environmental mastitis (e.g. Zdanowicz et al., 2004). There is some evidence that cows prefer lying down on straw rather than sand (Manninen et al., 2002), but this can be altered with greater experience of sand (Norrington et al. 2008). Furthermore, the reduced risk of mastitis or lameness (Cook, 2003; Espejo et al. 2006; Norring et al., 2008) with sand bedding may compensate for the lack of preference.

The configuration of free stalls (for example, size, position of neck rails, etc.) can also have a major effect upon cow comfort (Tucker et al., 2004, 2005, 2006). In addition to stall width, neck-rail placement is important for managing standing behavior. Both the height of the neck rail and its distance from the curb affect standing (Tucker et al., 2005); more restrictive neck-rail placements (lower and closer to the rear of the stall) prevent cows from standing fully in the stall and this in turn increases the time cows spend on concrete flooring elsewhere in the barn, increasing the risk of lameness as described below.

Stalls should provide a clean, comfortable area for cows to lie down. However, cows often stand in the stalls increasing the risk of feces falling onto the lying area. The common response by barn designers has been to make the stalls more restrictive, forcing cows back into the concrete alley. Keeping cows from using the stalls will keep the stalls clean - both narrow free stalls and the more restrictive neck rail placements reduce the amount of fecal matter that ends up in the stall. However, stall cleanliness alone is a poor measure of stall design. Free stalls that are more comfortable have higher occupancy rates and are therefore most likely to contain feces.

The real problem may not be in the design of the stall itself. In most barns the surface for standing outside of the stall is hard, wet concrete. Thus cows use the stall as a refuge from concrete floors -- it provides a dry, softer surface for standing. However, standing in the stall increases the likelihood that cows urinate and defecate on the stall surface, making it less suitable for lying. From this perspective we are stuck with two bad choices: use restrictive stalls that keep the stall surface cleaner but force cows back onto the wet concrete, or use more open designs and increase frequency of stall maintenance. However, there may be a third approach – improving the standing surface elsewhere in the barn.

***Improved surfaces for walking and standing.*** Research on cow comfort has tended to focus on the design of stalls to the exclusion of other important factors. According to popular thinking, when cows are not in the parlor they should be eating or lying down. Unfortunately, no one has explained this to the cows: even when cows have access to well-designed stalls they spend only about 12 h a day lying down. Cows spend the other 12 h a day on their feet, and we need to take this into account in designing suitable housing.

The majority of cows in free-stall housing now spend most of their time standing or walking on concrete floors, and the use of concrete floors has been identified as a risk factor for increased claw lesions and lameness (Somers et al. 2003, 2005, Vanegas et al. 2006). Free-stall barns with concrete

floors often have poor drainage, in part because some moisture improves the performance of automatic scraper systems, but when cows stand on wet floors the claws absorb water and become soft, increasing the risk of sole wear (Borderas et al., 2004) and sole lesions (van Amstel et al., 2004). The common use of concrete floors with poor drainage may explain why lameness and claw lesions are more common in free-stall systems, especially where the cows have no access to pasture (Haskell et al., 2006). Recent work has shown that cows prefer to stand on softer flooring (Tucker et al., 2006; Fregonesi et al., 2004). The development of new standing surfaces is an important area for future work.

Even when dry, there are two problems with concrete floors: often they do not provide sufficient traction to allow good cow mobility (van der Tol et al. 2005) and they may be too hard, increasing the pressure on the hooves (Franck and De Belie, 2006). Recently, Rushen and de Passillé (2006) showed that both surface friction and the ability of the floor to absorb shock were important in improving cow mobility, leading to an increase in walking speed and a reduction in the likelihood of the cow slipping. Rubber flooring reduces horn growth and wear (Vanegas et al., 2006), but little is known about alternative flooring surfaces and how these might reduce the risk of lameness and improve cow mobility.

**Barn layout.** Cow comfort may also be affected by overall layout of the barn. For example, some work has shown that cows rarely use certain stalls in a pen, while seemingly identical stalls are occupied more than 80% of the available time. One study (Gaworski et al., 2003) showed that stalls in the row closest to the feed alley were occupied 41% more frequently than were stalls in more distant rows. In addition, stalls located within the centre of each row were used 12% more often than those stalls located on the periphery of the row (i.e. either near a wall or fence). Natzke et al. (1982) also found that stalls on the periphery were used less than stalls in the interior of the row. These results suggest that certain stalls, particularly those farther from the feed bunk and on the periphery, are less desirable to dairy cattle perhaps because cows need to walk farther, or because of they have to navigate past certain physical (e.g. narrow alleys) or social obstacles (e.g. dominant cows) on their way to the more distant stalls. Indeed, earlier work has indicated that the movements of subordinate animals are prevented by the location of dominant cows (Miller and Wood-Gush, 1991). Such factors may partly explain reduced user satisfaction and lower production in those barn designs consisting of more rows (e.g. 6 and 4 row verses 2 and 3 row barns: Bewley et al., 2001).

Thus large differences in usage can occur even among identically configured stalls within the same barn. The fact that stalls within a pen vary in their popularity suggests that stall availability from the cows' perspective is not the same as from the producer's perspective -- what looks to us as 1:1 cow-to-stall stocking density may seem considerably worse to the cows if some stalls are unacceptable.

**Better feeding areas.** Despite decades of work focusing on the impact of changes in nutrition on dry matter intake there has been virtually no work addressing other factors that can affect intake, including the design and management of the feeding area. There are several aspects of the feeding environment that affect the cow's ability to access feed, including the amount of available feed bunk space per animal and the physical design of the feeding area. DeVries et al. (2004) showed that doubling feeding space from 0.5 m to 1.0 m per cow reduced by half the number of aggressive interactions while feeding. This reduction in aggressive behavior allowed cows to increase feeding activity by 24% at peak feeding times, an effect that was strongest for subordinate animals.

The physical design of the feeding area can also influence feeding behavior. One of the most obvious features of the feeding area is the physical barrier that separates the cow and the feed, and new research shows that some designs can reduce aggressive interactions at the feed bunk. For example, Endres et al. (2005) compared the effects of a post-and-rail versus a headlock feed line barrier on the feeding and social behavior of dairy cows and found that during periods of peak feeding activity (90 min after fresh feed delivery) subordinate cows had lower feeding times when using the post-and-rail barrier. This difference in feeding times was likely due to positive effects of the headlock barriers in reducing competitive interactions; there were also 21% fewer displacements at the feed bunk when cows accessed feed by the headlock barrier compared to the post-and-rail barrier.

In a second study we retested the effects of these two types of feed bunk barriers, but did so over a range of stocking densities (Huzzey et al., 2006). Cows were tested with the barriers described above but using stocking densities of 0.81, 0.61, 0.41 and 0.21 m/cow (corresponding to 1.33, 1.00, 0.67 and 0.33 headlocks/cow). Daily feeding times were higher and the duration of inactive standing in the feeding area was lower when using a post-and-rail compared to a headlock feed barrier. As well, regardless of barrier type, feeding time decreased and inactive standing increased as stocking density at the feed bunk increased. Cows were displaced more often from the feeding area when the stocking density was increased, and this effect was greater for cows using the post-and-rail feed barrier. Again we found that this effect was greatest for the subordinate cow, particularly at high stocking densities. Clearly, overstocking the feed bunk decreases time spent at the feed bunk and increases competition, resulting in poor feed access.

New work has now shown that providing additional partitions (“feed stalls”) between adjacent cows provides additional protection while feeding and allows for improved access to feed (DeVries and von Keyserlingk, 2006). Providing a feed stall resulted in less aggression and fewer competitive displacements, effects that were again greatest for subordinate cows. This reduced aggression allowed cows to increase daily feeding time and reduced the time they spent standing in the feeding area while not feeding. Thus the provision of more bunk space, particularly when combined with feed stalls, improves access to feed and reduces competition at the feed bunk, particularly for subordinate cows. This could help reduce the between-cow variation in the composition of ration consumed by preventing subordinate cows from being forced to access the bunk only after dominant cows have sorted the feed (DeVries et al., 2005). The use of a barrier that provides some physical separation between adjacent cows can reduce competition at the feed bunk. A less aggressive environment at the feed bunk may also have longer-term health benefits; cows engaged in aggressive interactions at the feed bunk are likely at higher risk for hoof health problems (Leonard et al., 1998). A final advantage of such stalls is that they can facilitate the use of alternative flooring surfaces in the feeding area, and access to a softer, drier standing area at the feeder can improve hoof health (Manske et al. 2002).

### **The “Transition” Cow**

The periparturient period or “transition” phase (generally accepted as the period beginning 3 weeks prior to calving and ending 3 weeks following calving) is one of the critical points in dairy production where risks to animal welfare are highest. During the transition period, cows face a number of stressors including diet changes and social regroupings, and the physical, hormonal and physiological changes associated with calving and the onset of lactation. One of the main challenges

for transition dairy cows is a sudden increase in nutrient requirements to support the onset of lactation at a time when dry matter intake lags behind (Drackley, 1999).

There are a well-known suite of disorders that afflict cows during transition, including ketosis, fatty liver, displaced abomasums, mastitis, metritis and retained placenta, and milk fever. Susceptibility to certain infectious diseases also peaks at this time (Smith et al., 1985). The high prevalence of infectious disease during transition may also be linked to inadequate nutrition (Goff 2006), as these diseases commonly occur as a secondary illness to primary metabolic disease (Reist et al., 2003). Inadequate nutrition may also contribute to a depression of the immune system during transition (e.g. Mallard et al., 1998; Hammon et al., 2006). Specifically, infectious agents that the body would eliminate under robust immune conditions are more likely to induce clinical infectious disease, especially in vulnerable areas such as the udder and uterus (Cai et al., 1994).

As veterinary examination of post-partum cows is relatively infrequent on most farms (commonly once every two weeks), many cases of transition period disease may go unnoticed. Producers can use urine or milk tests to monitor the health of their animals, but frequent administration of tests on a herd-wide scale can be costly and time-consuming. Moreover, no such tests are available for diagnosing inflammatory uterine disease (metritis or endometritis), one of the most common disorders after calving. Knight et al. (1999) suggested that animals that experience moderate metabolic stress after calving might sacrifice immune function for the sake of maintaining lactation, a considerably more important function at that time. Metabolic resources would not be diverted from lactation until a cow became severely metabolically stressed. Therefore, the common practice of using daily milk yield as a general indicator of animal health is a relatively insensitive method for identifying sick or at-risk animals. For example, milk production responds poorly to mild or subclinical infectious disease. In fact, Rajala-Shultz et al. (1999) found that cows with a fever produced more milk, on average, than did healthy cows. Thus, a more sensitive method of continuously monitoring animal health or risk for disease during the transition period is needed. Recent work (Urton et al. 2005; Huzzey et al. 2007) indicates that changes in feeding behavior and dry matter intake in the weeks prior to calving may be used to identify cows at risk for metritis post partum but more work is required to validate this approach.

### **Lameness**

Lameness is widely regarded as a major welfare problem for dairy cows, affecting milk production and feed intake (Bareille et al., 2003). Lameness can result from infectious disease (such as digital dermatitis and foot rot) or hoof lesions (e.g. ulcers, haemorrhages, white line separation) that are associated with both metabolic challenges and physical injury to the hoof. Nutritional factors such as wet silage can increase risks (Offer et al. 2003), but management factors, such as the use of concrete floors (Somers et al. 2003, 2005; Telezhenko and Bergsten, 2005; Vanegas et al., 2006), zero-grazing (Haskell et al. 2006) and uncomfortable stalls (Cook et al., 2004) are also important.

Unfortunately, producers find it difficult to identify animals at the early stages of lameness (Whay et al., 2003; Espejo et al. 2006), likely because dairy cows remain stoic unless injuries are relatively severe (O'Callaghan, 2002). Current research is developing improved gait scoring system that can be use to identify cows that are becoming lame. Better scoring systems will require improved knowledge of cows' gait, and this can be derived from computer-assisted kinematic techniques that

obtain precise measures of gait and how this changes with different types of hoof injuries (Flower et al., 2005). Our group uses a gait scoring system based on several specific gait features (e.g. asymmetric steps, tracking up etc.), and these scores have proven sensitive in identifying cows with sole ulcers (Flower and Weary, 2006), pain reduction following use a non-steroidal anti-inflammatory drug (Flower et al. 2008), and the advantages of softer walking surfaces for lame cows (Flower et al., 2007). Part of the difficulty in identifying lame cows may come from the fact that herd sizes are increasing leaving producers less time to spend watching their animals. This has led to interest in automated means of detecting lameness, such as through changes in how cows distribute the weight among the four limbs either when standing or walking (Rajkondawar et al., 2002; Neveux et al. 2006; Pastell et al., 2007), altered attendance at automated milking systems (Borderas et al., 2008), or automated image analysis (Song et al., 2008).

### **Conclusion**

This review has outlined a few key areas of concern regarding the welfare of dairy cattle housed in freestalls, and has shown how scientific research can help address these concerns. For example, new research has shown how indoor housing systems can be made more comfortable for adult cows and how common diseases like lameness and metritis can be better identified and prevented through improvements in the ways cows are housed and managed.

### **Acknowledgments**

General support for the UBC Animal Welfare Program is provided by Canada's Natural Sciences and Engineering Research Council and by contributions from the Dairy Farmers of Canada, the BC Dairy Foundation, members of the BC Veterinary Medical Association and many others listed at <http://www.landfood.ubc.ca/animalwelfare>

### **References**

- Bareille, N., F. Beaudeau, S. Billon, A. Robert, and P. Faverdin. 2003. Effects of health disorders on feed intake and milk production in dairy cows. *Livest. Prod. Sci.* 83:53-62
- Bewley, J., R. W. Palmer, and D. B. Jackson-Smith. 2001. A comparison of free-stall barns used by modernized Wisconsin dairies. *J. Dairy Sci.* 84, 528-541.
- Borderas, T. F., B. Pawluczuk, A. M. de Passille, and J. Rushen. 2004. Claw hardness of dairy cows: Relationship to water content and claw lesions. *J. Dairy Sci.* 87:2085-8093.
- Cai, T. Q., P. G. Weston, L. A. Lund, B. Brodie, D. J. McKenna, and W.C. Wagner. 1994. Association between neutrophil functions and periparturient disorders in cows. *Am. J. Vet. Research.* 55:934-943.
- Cook, N. B. 2003. Prevalence of lameness among dairy cattle in Wisconsin as a function of housing type and stall surface. *J. Am. Vet. Med. Assoc.* 223:1324-1328
- Cook, N. B., T. B Bennett, and K. V. Nordlund. 2004. Effect of free stall surface on daily activity patterns in dairy cows with relevance to lameness prevalence. *J. Dairy Sci.* 87:2912-2922.

- DeVries, T. J., and M. A. G. von Keyserlingk. 2006. Effects of feeder design on the social and feeding behaviour of lactating dairy cows. *J. Dairy Sci.* 89: 3522-3531.
- DeVries, T. J., M. A. G. von Keyserlingk, and D. M. Weary. 2004. Effect of feeding space on the inter-cow distance, aggression, and feeding behavior of free-stall housed lactating dairy cows. *J. Dairy Sci.* 87:1432-1438.
- DeVries, T. J., M. A. G. von Keyserlingk, and K. A. Beauchemin. 2005. Frequency of feed delivery affects the behavior of lactating dairy cows. *J. Dairy Sci.* 88:3553-3562.
- Drackley, J. K. 1999. Biology of dairy cows during the transition period: the final frontier? *J. Dairy Sci.* 82:2259-2273.
- Endres, M. I., T. J. DeVries, M. A. G. von Keyserlingk, and D. M. Weary. 2005. Effect of feed barrier design on the behavior of loose-housed lactating dairy cows. *J. Dairy Sci.* 88:2377-2380.
- Espejo, L. A., M. I. Endres, and J. A. Salfer. 2006. Prevalence of lameness in high-producing Holstein cows housed in freestall barns in Minnesota. *J. Dairy Sci.* 89:3052-3058.
- Flower, F.C., M. Sedlbauer, E. Carter, M. A. G. von Keyserlingk, D. J. Sanderson, and D. M. Weary. 2008. Analgesics Improve the Gait of Lame Dairy Cattle. *J Dairy Sci* 2008 91: 3010-3014.
- Flower, F. C., D. J. Sanderson, D. J. and D. M. Weary. 2005. Hoof pathologies influence kinematic measures of dairy cow gait. *J. Dairy Sci.* 88:3166-3173.
- Flower, F. C., A. M. de Passillé, D. M. Weary, D. J., Sanderson, and J. Rushen. 2007. Softer, higher friction flooring improves gait of cows with and without sole ulcers. *J. Dairy Sci.* 90: 1235-1242.
- Flower, F. C. and D. M. Weary. 2006. Effect of hoof pathologies on subjective assessments of dairy cow gait. *J. Dairy Sci.* 89:139-146.
- Franck, A., and N. De Belie. 2006. Concrete Floor–Bovine Claw Contact Pressures Related to Floor Roughness and Deformation of the Claw. *J Dairy Sci.* 89: 2952-2964.
- Fregonesi, J. A., C. B. Tucker, D. M. Weary, F. C. Flower, and T. Vittie. 2004. Effect of rubber flooring in front of the feed bunk on the time budgets of dairy cattle. *J. Dairy Sci.* 87:1203-1207.
- Fregonesi, J. A., D. M. Veira, M. A. G. von Keyserlingk, and D. M. Weary. 2007. Effects of Bedding Quality on Lying Behavior of Dairy Cows. *J Dairy Sci* 2007 90: 5468-5472.
- Gaworski, M. A., Tucker, C.B., and Weary, D.M. 2003. Effects of two free-stall designs on dairy cattle behavior. Pages 139-146 in Proc. of the Fifth International Dairy Housing Conference, American Society of Agricultural Engineers, St. Joseph, MI.
- Goff, J.P. 2006. Major advances in our understanding of nutritional influences on bovine health. *J. Dairy Sci.* 89:1292-1301.

- Haley, D. B., J. Rushen, and A. M. de Passille. 2001. Assessing cow comfort: effects of two floor types and two tie stall designs on the behaviour of lactating dairy cows. *Appl. Anim. Behav. Sci.* 71:105-117.
- Hammon, D.S., I. M. Evjen, T. R. Dhiman, J. P. Goff and J. L. Walters. 2006. Neutrophil function and energy status in Holstein cows with uterine health disorders. *Vet. Immun. Immunopath.* 113:21-29.
- Haskell, M. J., L. J. Rennie, V. A. Howell, M. J. Bell, and A. B. Lawrence. 2006. Housing system, milk production, and zero-grazing effects on lameness and leg injury in dairy cows. *J. Dairy Sci.* 89:4259-4266.
- Huzzey, J. M., T. J. DeVries, P. Valois, and M. A. G. von Keyserlingk. 2006. Stocking density and feed barrier design affect the feeding and social behavior of dairy cattle. *J. Dairy Sci.* 89:126-133.
- Huzzey, J.A., D.M. Veira, D.M. Weary, M.A.G. von Keyserlingk. 2007. Behavior and intake measures can identify cows at risk for metritis. *J. Dairy Sci.* 90:3320-3233.
- Knight C. H., D. E. Beever, and A. Sorensen. 1999 Metabolic loads to be expected from different genotypes under different systems. *British Society of Animal Science Occasional Publication* 24:27-35
- LeBlanc, S. J., K. D. Lissemore, D. F. Kelton, T. F. Duffield, and K. E. Leslie. 2006. Major advances in disease prevention in dairy cattle. *J. Dairy Sci.* 89:1267-1279.
- Leonard, F. C., I. Stienezen, and K. J. O'Farrell. 1998. Overcrowding at the feeding area and effects on behavior and claw health in Friesian heifers. Pages 40-41 in *Proc. 10th Int. Symp. Lameness in Ruminants*, Lucerne, Switzerland.
- Mallard, B. A., J. C. Dekkers, M. J. Ireland, K. E. Leslie, S. Sharif, C. Lacey Vankampen, L. Wagter, and B. N. Wilkie. 1998. Alteration in immune responsiveness during the peripartum period and its ramification on dairy cow and calf health. *J. Dairy Sci.* 81:585-595.
- Manske, T., J. Hultgren, and C. Bergsten. 2002. Prevalence and interrelationships of hoof lesions and lameness in Swedish dairy cows. *Prev. Vet. Med.* 54:247-263.
- Mayntz, M. and R. Costa. 1998. Effect of pharmacologically induced changes in milk ejection on suckling in *Bos taurus*. *Physiol. Behav.* 65:151-156.
- Miller K. and D. G. M. Wood-Gush. 1991. Some effects of housing on the social-behavior of dairy cows. *Anim. Prod.* 53:271-278.
- Natzke, R. P., D. R. Bray, and R. W. Everett. 1982. Cow preference for free stall surface material: Rubber mats, carpeting, and a layered mat. *J. Dairy Sci.* 25:146-153.
- Neveux, S., D. M. Weary, J. Rushen, M. A. G. von Keyserlingk, and A. M. de Passillé. 2006. Hoof

discomfort changes how dairy cattle distribute their body weight. *J. Dairy Sci.* 89:2503-2509.

Norring, M., E. Manninen, A. M. de Passillé, J. Rushen, L. Munksgaard, and H. Saloniemi. 2008. Effects of Sand and Straw Bedding on the Lying Behavior, Cleanliness, and Hoof and Hock Injuries of Dairy Cows. *J Dairy Sci* 2008 91: 570-576.

Offer, J.E., K.A. Leach, S. Brocklehurst, and D.N. Logue. 2003. Effect of forage type on claw horn lesion development in dairy heifers. *Vet. Rec.* 165:221-227.

O'Callaghan, K. A. 2002. Lameness and associated pain in cattle – challenging traditional perceptions. *In. Pract.* 24:212-219.

Pastell, M. E. and M. Kujala 2007. A Probabilistic Neural Network Model for Lameness Detection. *J Dairy Sci* 90: 2283-2292

Rajala-Schultz, P. J., Y. T. Grohn, and C. E. McCulloch. 1999. Effects of milk fever, ketosis, and lameness on milk yield in dairy cows. *J. Dairy. Sci.* 82:288-294.

Rajkondawar, P. G., U. Tasch, A. M. Lefcourt, B. Erez, R. M. Dyer, and M. A. Varner. 2002. A system for identifying lameness in dairy cattle. *Appl. Eng. Agric.* 18:87-96.

Reist, M., D. Erdin, D. von Euw, K. Tschuemperlin, H. Leuenberger, Y. Chilliard, H. M. Hammon, C. Morel, C. Philipona, Y. Zbinden, N. Kuenzi, and J. W. Blum. 2003. Estimation of Energy Balance at the Individual and Herd Level Using Blood and Milk Traits in High-Yielding Dairy Cows *J. Dairy Sci.* 85: 3314-3327.

Rushen J., and A. M. de Passillé. 2006. Effects of roughness and compressibility of flooring on cow locomotion. *J. Dairy Sci.* 89:2965-2972.

Smith, K.L., D.A. Todhunter, and P.S. Schoenberger. 1985. Environmental mastitis: cause, prevalence, prevention. *J. Dairy Sci.* 68:1531-1553.

Somers, J. G. C. J., K. Frankena, E. N. Noordhuizen-Stassen, and J. H. M. Metz. 2003. Prevalence of claw disorders in Dutch dairy cows exposed to several floor systems. *J. Dairy Sci.* 86:2082-2093.

Somers, J. G. C. J., W. G. P. Schouten, K. Frankena, E. N. Noordhuizen-Stassen, and J. H. M. Metz. 2005. Development of claw traits and claw lesions in dairy cows kept on different floor systems. *J. Dairy Sci.* 88:110-120.

Song, X., Leroy, T., Vranken, E., Maertens, W., Sonck, B., and Berckmans, D. 2008. Automatic detection of lameness in dairy cattle-Vision-based trackway analysis in cow's locomotion. *Comp. Electr. Agric.* 64:39-44

Telezhenko, E., and C. Bergsten. 2005. Influence of floor type on the locomotion of dairy cows. *Appl. Anim. Behav. Sci.* 93:183-197.

Tucker, C. B., D. Fraser, and D. M. Weary. 2001. Tail docking dairy cattle: effects on cow

cleanliness and udder health. *J. Dairy Sci.* 84:84-87.

Tucker, C. B., and D. M. Weary. 2004. Bedding on geotextile mattresses: how much is needed to improve cow comfort? *J. Dairy Sci.* 87:2889-2895.

Tucker, C. B., D. M. Weary, and D. Fraser. 2004. Freestall dimensions: effects of preferences and stall usage. *J. Dairy Sci.* 87:1208-1216.

Tucker, C. B., D. M. Weary, and D. Fraser. 2005. Neck-rail placement: effect on freestall preference, usage, and cleanliness. *J. Dairy Sci.* 88:2730-2737.

Tucker, C. B., M. Zdanowicz, D. M. Weary. 2006. Brisket boards reduce freestall use. *J. Dairy Sci.* 89:2603-2607.

Urton, G., M. A. G. von Keyserlingk, A. P. Viera, and D. M. Weary. 2005. Feeding behavior identifies dairy cows at risk for metritis. *J. Dairy Sci.* 88:2843-2849.

van Amstel, S. R., J. K. Shearer, and F. L. Palin. 2004. Moisture Content, Thickness, and Lesions of Sole Horn Associated with Thin Soles in Dairy Cattle. *J Dairy Sci.* 87: 757-763.

van der Tol, P. P. J., J. H. M. Metz, E. N. Noordhuizen-Stassen, W. Back, C. R. Braam, W. A. Weijs. 2005. Frictional forces required for unrestrained locomotion in dairy cattle. *J. Dairy Sci.* 88:615-624.

Vanegas, J., M. Overton, S. L. Berry, and W. M. Sisco. 2006. Effect of Rubber Flooring on Claw Health in Lactating Dairy Cows Housed in Free-Stall Barns. *J Dairy Sci.* 89: 4251-4258.

Whay, H. R., D. C. J. Main, L. E. Green, and A. J. F. Webster. 2003. Assessment of the welfare of dairy cattle using animal-based measurements: direct observations and investigation of farm records. *Vet. Rec.* 153:197-202.

Zdanowicz, M., J. A. Shelford, C. B. Tucker, D. M. Weary, and M. A. G. von Keyserlingk. 2004. Sand and sawdust bedding affect bacterial populations on teat ends of dairy cows housed in freestalls. *J. Dairy Sci.* 87:1694-1701.

# Employing Aliens: Straddling the Barbed Wire Fence<sup>1</sup>

Ben Yale  
Yale Law Office  
P.O. Box 100136  
Waynesville, OH 45896  
419-568-5751  
[ben@yalelawoffice.com](mailto:ben@yalelawoffice.com)

## Summary

Of your employment practice, you should establish and implement a written policy and procedure for responding to no match letters and maintain records of your responses to those letters and communications with affected employees. Apply the policy consistently to all employees in order to avoid claims of discrimination.

This procedure applies if you as an employer receive from the Social Security Administration (SSA) an “Employer Correction Request” (commonly referred to as a “No-Match Letter”) or notice from the Department of Homeland Security (DHLS) that the immigration status or employment-authorization documentation presented or referenced by the employee in completing Form I-9 was not assigned to the employee according to Department of Homeland Security records. Both of these will be called “No-Match Letters.”

Make and identify a folder to hold all correspondence regarding No-Match Letters. Make the folder readily accessible and keep in it all correspondence between you and SSA, employees, and DHLS regarding any Immigration looms over the dairy industry like a large dark storm capable at any moment to break forth in a widespread wind and rain torrent or a more focused tornado, damaging much of the industry or destroying just a few. No matter where one looks, there is no light to be seen promising fairer weather though political forecasters predict relief will come, sometime. Dairy men, like much of American agriculture, rely upon immigrant labor despite the fact that many such workers are likely aliens unauthorized for employment in the US. American immigration and economic policy has effectively allowed and even encouraged the use of this labor. The U.S. Congress has failed to provide another clear, less risky, means to satisfy the legitimate need for labor with a workable and sufficiently sized program that provides labor to maintain economic stability and protects our national security.

The current visa programs are inadequate both in terms of numbers of available visas as well as the unworkable process. Dairy Farmers, as most are agricultural employers, depend upon a mostly Hispanic work force. Some of these employees may not be authorized to work in the United States (Undocumented Workers) but are able to obtain employment by falsely filling out Form I-9 or providing forged documents in support of their claims. An employer cannot be sure whether or not an employee is authorized while illegal to hire alien workers that are not properly documented. Current Federal law provides employers protections. Such does not protect employers from losing valuable employees as a result of government raids, arrests, and other efforts to identify and remove undocumented alien workers. In the vacuum of Federal law, states and local governments are

---

<sup>1</sup>Copyright 2009, Ben Yale, Waynesfield Ohio.

entering into the area of civil enforcement of immigration laws. This presentation will provide a detailed look at how an employer should comply with Federal law, explain the changes in Federal regulations, will examine the proposed Federal legislative and regulatory changes, and examine recent efforts at state regulation such as in Arizona.

### **Background**

In dairying, the use of Hispanic laborers is widespread and generally viewed as the preferred method of staffing dairy farms. This is because of their strong work ethic, attention to details during repetitive tasks, reliability, and trustworthiness. Contrary to popular perception and media suggestions otherwise, compensation for these workers typically includes benefits, housing, and a competitive wage. The compensation package compares favorably with other jobs in the community for workers with similar skill sets.

These workers include native born American citizens, lawful and fully documented alien workers from Mexico, Guatemala, and other Latin American countries, and improperly documented workers. The distribution of these categories among all of the dairy workers is not known. Distribution at individual dairy farms is even harder to know. Speculation runs from none to all with all percentages in between. The two extremes cannot be true. It is safe to say, however, that there are significant numbers of undocumented alien workers among the work force.

Who is and who is not an authorized worker cannot be known by merely looking at the individual. At the same time, Federal law severely limits the amount of information an employer may obtain to conform to existing Federal immigration laws. From the standpoint of a dairy farmer employer who fully complies with the Federal rules, all of its workers are properly documented workers, alien or citizen. But compliance with Federal law is only part of the issue for a dairyman.

Even if the employer is in full compliance, that does not mean the employees are. Any authorized alien is subject to removal from employment, not uncommonly in raids by Immigration Control and Enforcement (ICE) officers. Such actions not only can unexpectedly and severely deplete the work force of a dairyman, but will also frighten those who are lawfully here. This leaves gaps in the filling of key skilled positions and the inability to fill those gaps.

Since Congress has failed to adequately address this situation, the agencies have taken harder stances on the existing law. The issue is not only being fought in the legislatures and agencies, but in the courts as well. At the time of writing, a San Francisco court continues to stay enforcement of tougher DHS regulations on “no match” letters. Briefs are due the end of February 2009. To make things more difficult, more and more states and localities have passed bills addressed at unlawful alien workers. These, often Draconian measures, further interfere with filling skilled positions by depleting the workforce and scaring the remaining workers away.

### **The Law**

The Constitution gives the Federal government the right to establish rules concerning immigration and naturalization.<sup>3</sup> Under Federal law, it is unlawful to hire an alien who is not authorized to work. On its surface, it is an easily understood law.

It is unlawful for a person or other entity-(A) to hire, or to recruit or refer for a fee,

---

<sup>3</sup>U.S.C.A. Const. Art. I § 8, cl. 4.

for employment in the United States an alien knowing the alien is an unauthorized alien . . . with respect to such employment,<sup>4</sup>

More to the status of dairy farmer employers, it is unlawful to fail in complying with Form I-9 procedures:

It is unlawful for a person or other entity. . . if the person or entity is an, agricultural employer, . . .to hire, or to recruit or refer for a fee, for employment in the United States an individual without complying with the requirements of subsection (b) of this section.<sup>5</sup>

Violations of either section can be costly. Violating the paper work requirements of I-9 run from \$100 to \$1000 for each individual employee in which the paperwork is not in order.<sup>6</sup> Factors to be considered are the size of the business of the employer being charged, the good faith of the employer, the seriousness of the violation, whether or not the individual was an unauthorized alien, and the history of previous violations.<sup>7</sup>

Criminal penalties for violation of hiring an unauthorized alien or continuing to hire one after it is known that he is not authorized are up to \$3000 per unauthorized alien and up to six months imprisonment for the entire practice or pattern regardless of the number of aliens.<sup>8</sup> Injunctive relief can also be issued.<sup>9</sup> There are no criminal violations for failure to comply with the I-9 process.

Good faith compliance with Form I-9 is a defense to the prohibition to hire an unauthorized alien. The regulations for subsection (b) of the statute are embodied in rules found at 8 CFR 274a.<sup>10</sup> These are described in more detail later.

The result is that for employers it is the failure to comply with documentation procedures that creates liability.

### **Safe Harbor Provisions**

---

<sup>4</sup>8 U.S.C. A. §1324a(a)(1)(A).

<sup>5</sup>8 U.S.C. A. §1324a(a)(1)(B)

<sup>6</sup>8 U.S.C.A. §1324a(a)(5)

<sup>7</sup>8 U.S.C.A. §1324a(a)(5)

<sup>8</sup>8 U.S.C.A. §1324a(f).

<sup>9</sup>8 U.S.C.A. §1324a(f)(2)

<sup>10</sup>8 CFR Part 274a, CONTROL OF EMPLOYMENT OF ALIENS.

Employers who follow the procedures required for Form I-9 will find themselves protected from both civil and criminal prosecution for either violation of (1)(a), (1)(b) or (2). The steps to fit in this “safe harbor” are as follows

- Use the current Form I-9 (11-07-2007) (A copy of the current form is attached)
- Have a new employee fill out the I-9 within 3 days of hire
- Employee provides documents that identify her or him and show that she or he is eligible for employment.
- Employee fills out the Section I "Employee information and verification"
- Employee Verifies it is true by signing.
- Employer inspects and reviews the identification and eligibility documents. If they appear to be what they purport to be, employer has complied.
- The Employer completes Section II, again within 3 days of hire after Employee has completed the Section I.
- Employer keeps form. The Employer does not file with the Immigration Service.
- These documents should be kept for three years or until one year after the employee is terminated, whichever is later.

There is a controversy over whether or not to photocopy the documents presented. This is a decision which each employer must make. In making the decision, the employer must consider a number of factors. First, these documents can only be used for the I-9 and cannot be used for any other purpose including numbers and addresses for employee compensation. Second, there is no requirement that the documents be copied. Failure to copy will not subject employer to any sanction. Third, having copies of the documents cannot help or augment an employer’s defense.

Making copies does have its risks. First, all employees must be treated the same. Having copies of some, but not all, employees can be the basis of an illegal discrimination claim. Second, facially the documents may not, in good faith, be what they purport to be. Having copies will provide authorities to challenge the employer’s good faith. Third, having some documents, but not all, could be interpreted to mean the employer did not really have the documents in hand at any time for those it does not have copies. Fourth, the documents can be used as prosecution of the employers’ employees and provide grounds for warrants and further investigation. In summary, there is neither necessity nor benefit to have copies, but plenty of risk.

The Form I-9s can be stored electronically. Whether electronically or physically, the I-9s and a list of employees should be kept in one file folder and not among all of the employees individually.

The Form I-9 is available in Spanish at the ICE website. *Only employers in Puerto Rico* can use the form. However, it may be useful to provide to employees to see what they are filling out. A copy is attached to this report to be used for explanation to would be hires.

#### **Documents to be used.**

A would be employee must provide documents that establish identity and eligibility. The Department of Homeland Security has provided three lists (List A, B, and C) of proper documents. List A includes documents that provide both identity and eligibility. These are US Passport (expired or not), Alien Registration Receipt Card or Permanent Resident Card, Form I-551, unexpired foreign

passport with temporary I-551 stamp, unexpired Employment Authorization Document issued by INS containing photograph, unexpired foreign passport with Form I-94. If a worker provides one of those documents, then all requirements of the Employee under I-9 are satisfied.

If the employee does not have a document from List A, then she must provide two documents—one from each of List B and List C. List B is an identity only document and includes drivers license or ID with photograph or with name, DOB, sex, height, color of eyes, address; a school ID with photo; a voter's registration card; US military card or draft record; military dependents ID card; U.S. Coast Guard Merchant Mariner Card; a Native American Tribal Document; or a Canadian driver's license. A driver's license issued by any governmental identity from Mexico is not valid under List B.

Employment authorization only documents (List C) include Social Security Card without "not valid for employment purposes" statement; Certification of Birth Abroad; original or certified birth certificate; Native American tribal document; US Citizens ID Card; Resident citizen ID Card; Unexpired employment authorization document by DHS.<sup>11</sup>

If the individual cannot provide the required documents because they were damaged, destroyed, or stolen, then the individual can still comply by providing a receipt that shows replacement documents have been requested and, within 90 days, supply the replacement document.

Minors and handicapped individuals must supply the same documents, but their application can be signed by their power of attorney, parent, or guardian.

#### **Changes in the No Match Rules.**

Department of Homeland Security has issued new regulations as to how it will interpret the constructive notice exception to the safe harbor when employers receive No-Match Letters.<sup>12</sup> The implementation is, as of this writing, subject to a court ordered injunction.<sup>13</sup>

There are cases of constructive notice which can remove the employer from the Safe Harbor provisions. These include "No-Match Letters" which inform the employer that the documents submitted are not true documents. From Social Security Administration employers may receive "Employer Correction Request" in matching annual W-2 reports with the database. Or from the Department of Homeland Security – ("Notice of Suspect Documents") which will come after an ICE audit of the employers I-9 records.

The SSA only sends letters to employers if there are multiple no matches (generally ten or more). Individual no-matches are sent to the employees at the addresses on their W-4 forms. SSA has stated that it will not send any no-match letters concerning more than one worker until the California federal lawsuit is settled. SSA will continue to send individual no-match letters to workers but will

---

<sup>11</sup>8 C.F.R. 274a.2

<sup>12</sup>Safe-Harbor Procedures for Employers Who Receive a No-Match Letter: Clarification; Initial Regulatory Flexibility Analysis, 73 Fed. Reg. 15944 (March 26, 2008).

Safe Harbor Procedures for Employers Who Receive a No-Match Letter: Clarification; Final Regulatory Flexibility Analysis 73 Fed. Reg. 63843 (October 28, 2008).

<sup>13</sup>AFL-CIO v. Chertoff *American Federation of Labor v. Chertoff*, 2007 WL 2972952 (ND Cal. 2007).

not send them to the worker's employer. No match letters from DHLS which come after an audit probably will continue.

Under the rules now on court ordered hold, if the "No Match Letter" is due to Clerical Error, within 30 days the employer should make sure that its records are correct and there is no typographical, transcription, or clerical errors. If there are they should be corrected, an amended W-4 transmitted to SSA and report the corrected numbers to SSA or DHLS as the case may be. Verification of SSA numbers can be done electronically.

If the "No Match Letter" is due to Employee Error, within 30 days verify with employee that the information employer has agrees with employee. If it does not, then correct the errors, file the amended transmittal of W-4, verify they are correct, and Report to the SSA or DHLS.

If the discrepancy is not resolved within 93 days of receipt of the letter, then the employee must file a new I-9 and the employer comply with the I-9 rules. The employee cannot use any document with the number being challenged and identification must be by photograph.

Homeland Security issued these rules intended to strengthen the obligation of employers to recheck those documents presented in support of authorization. These regulations would mandate conduct in response to the "no match" rules. In response a lawsuit was filed seeking injunctive relief against enforcement.<sup>14</sup> The court issued a preliminary injunction and set a date for hearing on a permanent injunction. Rather than appeal the decision, the government agreed to an extended injunction as it considers rewriting the rules and upgrading the SSA system to insure accuracy of the name and social security matches. After it filed new justification for the regulations, the government asked the stay to be lifted, but the Court did not.

### **E-Verify Rules**

General Services Administration (GSA) and other agencies issued final regulations on the use of E-verify for contractors with the government.<sup>15</sup> In its original form it would have required producers who had contracts with USDA for farm programs as well as other related agreements to participate in the E-verify program. The final rule exempts almost all producers of food and agricultural products that are "commercially available off the shelf". (COTS items). Farmers who provide bulk food are exempt. It also describes coop members as subcontractors which means that they are exempt even if other activities and products of the cooperative would be. The rules were effective January 15, 2008. The rule can be found at the government website, <http://origin.www.gpoaccess.gov/fr/>.

### **Department of Justice, Office of Special Counsel guidance for compliance with the No-Match Letters**

It is unlawful to discriminate in employment based upon citizenship, immigration status, or national origin.<sup>16</sup> Termination of an employee because employer received a no-match letter can be

---

<sup>14</sup>Id.

<sup>15</sup>Federal Acquisition Regulation; FAR Case 2007-013, Employment Eligibility Verification, 73 Fed. Reg. 67651 (November 14, 2008).

<sup>16</sup>8 U.S.C.A. §1324b.

the basis for a violation of that law. When DHLS issued the clarified rule on safe harbor provisions, Department of Justice, Office of Special Counsel, which handles discriminatory claims filed a notice in the Federal Register. The most important provisions are:

An employer that receives an SSA nomatch letter and terminates employees without attempting to resolve the mismatches, or who treats employees differently or otherwise acts with the purpose or intent to discriminate based upon national origin or other prohibited characteristics, may be found by OSC to have engaged in unlawful discrimination. However, if an employer follows all of the safe-harbor procedures outlined in DHS's no-match rule but cannot determine that an employee is authorized to work in the United States, and therefore terminates that employee, and if that employer applied the same procedures to all employees referenced in the no-match letter(s) uniformly and without the purpose or intent to discriminate on the basis of actual or perceived citizenship status or national origin, then OSC will not find reasonable cause to believe that the employer has violated section 1324b's antidiscrimination provision, and that employer will not be subject to suit by the United States under that provision.<sup>17</sup>

### **State enforcement of criminal and civil immigration laws**

In the past states have had the ability and often aided in the enforcement of criminal laws regarding alien employment. In the absence of Federal efforts and as a rise of populism grows, more and more states are becoming involved in civil enforcement. The first of these are Arizona's "Legal Arizona Workers Act"<sup>18</sup> and Oklahoma's "Oklahoma Taxpayer and Citizen Protection Act of 2007"<sup>19</sup> These have been followed by Mississippi's Mississippi Employment Protection Act,<sup>20</sup> Missouri<sup>21</sup>, South Carolina,<sup>22</sup> Utah,<sup>23</sup> and West Virginia.<sup>24</sup>

Each of the state laws has their individual approaches, but all have some things in common. The Arizona and Oklahoma statutes were the models for those that followed and can be used to

---

<sup>17</sup>Civil Rights Division; Office of Special Counsel's Antidiscrimination Guidance for Employers Following the Department of Homeland Security's Safe-Harbor Procedures, 73 Fed. Reg. 63993 (October 28, 2008).

<sup>18</sup>Oklahoma Laws 2007, Ch. 279

<sup>19</sup>Oklahoma Sess. Law Serv. Ch. 112 (H.B. 1804)

<sup>20</sup>Laws 2008, Ch. 312, eff. July 1, 2008

<sup>21</sup>V.A.M.S. 285.525 to 285.550, Mo. St. 285.525, (L.2008, H.B. Nos. 1549, 1771, 1395 & 2366, § A, eff. Jan. 1, 2009).

<sup>22</sup>Code 1976 §41-1-30.

<sup>23</sup>U.C.A. 1953 §63G-11-103.

<sup>24</sup>W. Va. Code, §§ 21-1B-1 - 7.

understand the breadth of the regulations. Each state will have to be analyzed individually and applied to specific facts. Nevertheless, some general observations can be made. Under the Arizona statute, which took effect at the beginning of 2008, all employers are required to participate in the basic pilot program offered by Homeland Security.<sup>25</sup> Under this program, employers register with DHS and enter into an agreement whereby that they will pre-screen all employees for compliance with worker authorization. In simple terms, through use of the internet, employers can enter names and social security or employment authorization numbers and have these verified in real time. With verification, the employee is authorized, otherwise not. All employees must be subject to E-verify. Complaints that the database behind the E-verify program is subject to gross error is the basis of the injunction pending against the Federal rules for “No Match Letters.”

Although the Arizona act does require participation in the Federal basic pilot program, there appears to be no penalty for failure to do so. As an affirmative rebuttable presumption that an employer did not intentionally employ an unauthorized alien, an employer may raise the defense available under the Federal statute that good faith compliance with the I-9 program is an affirmative defense.<sup>26</sup>

In Arizona if a business is found to have intentionally hired an illegal alien, then among other things its right to continue as a business can be suspended for up to ten days. The implications of this are enormous. Anyone can report suspicions to law enforcement officers and upon receipt of such a complaint, the agency is required to investigate.<sup>27</sup> In substance the Arizona statute appears to have created an obligation on the state enforcement agencies to enforce civil compliance with immigration laws and, where the law has been violated, exact state punishment as well. The psychological effect may be much greater as shown by reports of businesses shutting down and aliens fleeing the state in anticipation of the law.<sup>28</sup> The Ninth Circuit Court of Appeals held that (1) the act was licensing measure that fell within savings clause of Immigration Reform and Control Act's (IRCA) preemption provision; (2) the act was not impliedly preempted by IRCA; and (3) the act did not, on its face, violate employers' right to procedural due process.<sup>29</sup> The Missouri law has also been upheld.<sup>30</sup>

The Oklahoma statute goes beyond the Arizona act. In addition to employment related actions, it prohibits the transporting or harboring of aliens or “reckless disregard” of such fact. Punishment is no less than one year imprisonment and \$1000 fine.<sup>31</sup> Because these are not “employment actions”

---

<sup>25</sup>AZ St §23-214.

<sup>26</sup>AZ ST §23-212(I).

<sup>27</sup>AZ ST §23-212(B) & (C).

<sup>28</sup>Blog Entry: Arizona Illegal Alien Employment Law Having an Impact, [http://bordersense.com/blog\\_details.asp?blogid=55](http://bordersense.com/blog_details.asp?blogid=55) (January 7, 2008).

<sup>29</sup>*Chicanos Por La Causa, Inc. v. Napolitano*, 544 F. 3d 976 (9<sup>th</sup> Cir. 2008).

<sup>30</sup>*Gray v. City of Valley Park, Mo.*, Slip Copy, 2008 WL 294294, E.D.Mo., January 31, 2008.

<sup>31</sup>OK ST T. 21 §446.

there is no “safe harbor” and an employer otherwise immune from prosecution for hiring an unauthorized alien could be guilty of transporting or harboring them if she provides transportation of any kind or housing. State agencies in Oklahoma are prohibited from providing identification cards to unauthorized aliens.<sup>32</sup> As relevant to dairy farmers, Oklahoma requires that employers participate in the E-Verify program beginning July 1, 2008 to verify employment.<sup>33</sup> The punishment is that discharge of any employee if it has employed an unauthorized alien, has been improperly discharged.<sup>34</sup>

Of particular concern is that Oklahoma and many of the other states have created a cause of action for dismissing a U.S. citizen or authorized alien worker if the position is filled by an authorized alien.<sup>35</sup> Finally, most of the state laws provide for private reporting of violations and obligations on state officials to investigate.<sup>36</sup> The Oklahoma statute was held invalid by a Federal District Court. That decision is currently on appeal.<sup>37</sup>

The impact of legislation has other, unexpected, results. Denying benefits to illegal aliens for workers compensation, education, unemployment, insurance, and health care can fall back on the employer who may have an independent or moral obligation to provide those benefits.

### H-2A Visas

In the complexity of immigration law there has been a long standing provision for non immigrants to provide seasonal labor. A H-2A worker is a non immigrant worker here temporarily or for seasonal work fully intending to return to the native country. The moniker, “H-2A”, comes from the portion of the code, 7 U.S.C.A. 1101(a)(15)(H)(ii)(a) which provides visas for a limited number of persons

(a) having a residence in a foreign country which he has no intention of abandoning who is coming temporarily to the United States to perform agricultural labor or services, as defined by the Secretary of Labor in regulations and including agricultural labor defined in section 3121(g) of Title 26, agriculture as defined in section 203(f) of Title 29, and the pressing of apples for cider on a farm, of a temporary or seasonal nature.<sup>38</sup>

Recently, under attack for the complexity of the regulation, the Department of Labor issued no

---

<sup>32</sup>OK ST T. 21 §1550.42.

<sup>33</sup>OK ST. T. 21 §1313.

<sup>34</sup>Id.

<sup>35</sup>See, e.g., U.C.A. 1953 §63G (Utah).

<sup>36</sup>See, e.g., V.A.M.S. 285.525 to 285.550 (Missouri).

<sup>37</sup>*Chamber of Commerce of the United States of America v. W. A. Drew Edmondson*, Tenth Cir. Case No. 08-6127.

<sup>38</sup>7 U.S.C.A. 1101(a)(15)(H)(ii)(a)

regulations regarding H-2A visas.<sup>39</sup> NMPF and other dairy interests proposed allowing a definition of “temporary” that was consistent with the needs of dairy farmers whose “season” is year long. They modeled the proposal after a similar provision for sheepherders. DOL recognized the request but denied it saying it was not legislatively provided. It is questionable whether the law which provides for “temporary or a seasonal nature” can cover periods of at least a year which is necessary for dairy producers. Legislation will be required.

### **Forthcoming Legislation**

In the midst of this stalemate, Congress will be forced to address the issue. The E-verify program is up for renewal in March 2009 and its extension could come with some relief. The reality is that Congress needs to hear from you and what you need to maintain economic vitality today.

It is expected that the agency will continue to find ways to reduce the availability of the safe harbor now used by employers. In addition to the “no Match” letters, HLS has indicated it will continue to find ways to find that current practices constitute “recklessness” and thus void the safe harbor. The San Francisco court’s decision will give some clarity there.

The government did issue new H2A visa regulations, but the program needs overhauled or another one to meet the needs of dairy farmers.

As the government succeeds in making the SSA name and number matching program effective, employers on a national level will be required to use E-verify. Under e-verify employers are required to verify either the social security number of the work authorization number *before* employment. At the same time the “No-match” rules will be fully implemented regarding existing employees.

The states will continue to expand their role in enforcing immigration laws, not only criminally, but civilly.

### **What’s a dairyman to do?**

These present challenging times. There are no clear answers. Faced with a need for labor on one hand, a system that does not assure authorized workers on the other, and prohibited from denying employment based on immigrant status, there are a lot of risks. DHS has identified three characteristics of companies that it raids.<sup>40</sup> One of those three, national security and transportation infrastructure, does not apply to the dairy. The other two might. First, if the company appears to use as its business model the use of immigrant labor, it comes in the target range. That is why there have been high profile raids on meat packing and processing plants that bus in hundreds of labors the vast majority of which are immigrants. The second is that the company participates in the supplying of false documents.

This second one should not even be on the radar of a dairy farm. Look carefully over how you hire employees. Do you or any of your employees provide information directly or indirectly to assist immigrants in getting documents. The clearly illegal act would be actually furnishing documents.

---

<sup>39</sup>Changes to Requirements Affecting H–2A Nonimmigrants, 73 Fed. Reg. 76981 (December 18, 2008).

<sup>40</sup>“ Myth vs. Fact: Worksite Enforcement”, Leadership Journal, Department of Homeland Security, July 11, 2008, p. 3. <http://www.dhs.gov/journal/leadership/labels/E-Verify.html>

Don't! Make absolutely sure no supervisor, manager or other officer has any such documents. There is no rationale for someone holding identification records outside of the ordinary course of business. It is one reason some recommend no copies of documents supplied for I-9 application. You do not have to have documents to be liable. Even referring applicants to places or individuals that you think may supply them could be enough. If any of this has occurred on your farm, contact an attorney right now for advice on how to handle that fact. In some of the raids is that top management has taken a "blind eye" to subordinates doing just these things. If you have good reason to know that one of your workers submitted false documents, terminate the employment.

Addressing, the primary reason a dairyman might be targeted, the model calls for immigrant labor, there are things a dairyman can do to minimize the exposure. These are all important.

- Keep your mouth shut about who your employees are and where you think they came from. It is no one else's business and what you say can be repeated, restated, and reported in a way that can harm you and your business.
- Screen employees with an eye to whether or not they are potential troublemakers. Where have they worked before? Why are they not working there now? Check them out.
- If you have concrete evidence that contradicts an applicant's statements that they are authorized to work in the US, note the information you had in your records and do not hire the person.
- Avoid dealing with companies that advertise they can supply immigrant workers with proper documents. At least investigate fully before signing on. Such brokers are under a great deal of scrutiny and even if you acquired a properly documented worker, you still might be investigated because of the broker.
- Take all "no match letters" seriously and timely and properly respond to each and everyone of them.
- Post all vacancies with the local employment or state jobs office.
- Support your local sheriff. Keep an open line of communication with law enforcement. Introduce them to the management team. Make it clear to them that you will not tolerate illegal activity by your employees and support your word with action if it is reported.
- Avoid publicity and absolutely prohibit anyone from advertising, broadcasting, or filming any of your workers. Signs prohibiting photography should be posted in and about the barns and corrals.
- Work with the schools where workers attend. Assist in tutoring and other activities. Make sure workers know that there has to be no tolerance for violence anywhere.
- Instruct employees to be careful what they do on and off of the farm. Do not speed, do not drive without a license, do not get into fights.
- Instruct employees to avoid actions that draw attention to them, particularly in unfriendly ways.
- Find and retain an attorney in immigration now, introduce her or him to your

management team now, not when you need an attorney. Keep the attorney up to date on what is happening and give a “heads up” if you have concerns something might happen. It could be too late to find one when things happen.

Even with all of that a raid is possible. So, have an action plan in place should one happen. Go over things that need done the first ten minutes, the first hour, the first milking, the first day. What would have to be done? What could be delayed? Who could do it? All of these are questions that need to be considered and answered now. Put the plan in writing. Go over the plan with others in your operation. The day this happens may be the day you are in the plane to Hawaii. Practice it.

Join with other dairymen and create an emergency milking team in the case of any disaster that impacts the milking team (such as a tragic loss of several employees by a car accident or a raid). More than having an agreement, actually have the teams practice occasional milking in the other farms.

Establish, test and practice different means of communicating with everyone on the farm in the event of a raid.

### **Conclusion**

Dairymen continue to need good, skilled labor. A major source of that quality labor is immigrant. Hiring immigrant labor brings conflicting risks. Congress has still failed to address the issue. Pressures from state legislatures and agencies makes the task even more daunting. As dairymen, dealing with the vagaries of weather, disease, death, and other natural disasters prepares us for these risks. Knowing what the risks are, avoiding those that can be avoided, limiting those that can be limited, and keeping an eye on the rest provides the best protection at this time.

**APPENDIX A**  
**USEFUL WEBSITES**

**A. Government Websites**

U S Custom and Immigration Services, <http://www.uscis.gov/portal/site/uscis>

U.S. Department of Justice, Civil Rights Division, Office of Special Counsel for Immigration-Related Unfair Employment Practices. <http://www.usdoj.gov/crt/osc/>

**B. Immigration Discussion sites**

New York Times, Times Topics, Immigration and Refugees  
[http://topics.nytimes.com/topics/reference/timestopics/subjects/i/immigration\\_and\\_refugees/index.html](http://topics.nytimes.com/topics/reference/timestopics/subjects/i/immigration_and_refugees/index.html)

**C. Websites with helpful information for employers of immigrants**

Social Security Administration “No-Match” Letter Toolkit (3<sup>rd</sup> Edition)

[http://www.nilc.org/immsemplymnt/SSA-NM\\_Toolkit/index.htm](http://www.nilc.org/immsemplymnt/SSA-NM_Toolkit/index.htm)

**D. Laws and Regulations**

Safe-Harbor Procedures for Employers Who Receive a No-Match Letter: Clarification; Initial Regulatory Flexibility Analysis, 73 Fed. Reg. 15944 (March 26, 2008). “Federal Register: Simple Search” <http://www.gpoaccess.gov/fr/search.html> , Select Volume 73 and in the Search enter “page 15944” including the quotes.

Safe Harbor Procedures for Employers Who Receive a No-Match Letter: Clarification; Final Regulatory Flexibility Analysis 73 Fed. Reg. 63843 (October 28, 2008). “Federal Register: Simple Search” <http://www.gpoaccess.gov/fr/search.html> , Select Volume 73 and in the Search enter “page 63843” including the quotes.

Civil Rights Division; Office of Special Counsel’s Antidiscrimination Guidance for Employers Following the Department of Homeland Security’s Safe-Harbor Procedures, 73 Fed. Reg. 63993 (October 28, 2008). “Federal Register: Simple Search” <http://www.gpoaccess.gov/fr/search.html> , Select Volume 73 and in the Search enter “page 63993” including the quotes.

Regulations regarding employment of aliens: Title 8--Aliens and Nationality Chapter I--department of Homeland Security Part 274a--control of Employment of Aliens can be found at the GPOACCESS website, [http://www.access.gpo.gov/nara/cfr/waisidx\\_08/8cfr274a\\_08.html](http://www.access.gpo.gov/nara/cfr/waisidx_08/8cfr274a_08.html)

The law regarding Unlawful Employment of Aliens: 8 U.S.C. 1324a

Go to the United States Code: Main Page, <http://www.gpoaccess.gov/uscode/index.html> In search type 8usc1324a, no spaces.

You may contact me [ben@yalelawoffice.com](mailto:ben@yalelawoffice.com)

## APPENDIX B

### SUGGESTED STEPS TO FOLLOW IF YOU RECEIVE A SOCIAL SECURITY “EMPLOYER CORRECTION REQUEST” OR “NO-MATCH LETTER”

Department of Homeland Security has issued regulations regarding how to handle “no-match” letters and maintain the protection of the “safe harbor” under the law. The regulations found at 8 C.F.R.274a and the explanation of why the no match provisions are written the way they are is found at Safe-Harbor Procedures for Employers Who Receive a No-Match Letter: Clarification; Initial Regulatory Flexibility Analysis, 73 Fed. Reg. 15944 (March 26, 2008) and Safe Harbor Procedures for Employers Who Receive a No-Match Letter: Clarification; Final Regulatory Flexibility Analysis 73 Fed. Reg. 63843 (October 28, 2008). They are currently subject to a court injunction. That may or may not be lifted. Assuming they do take affect, the following addresses ways in which to handle receipt of no-match letters. These are suggestions, you should have on your “team” a lawyer who understands immigration issues and advises you on practice and procedure.

1. As part and all mismatches. Also make notes of all phone calls, conversations, emails, and other communications with anyone regarding the No-Match Letters. These notes should include no less than the date, approximate time, those present, nature of the conversation, and any promises made. Keep the folder in a safe and secure location.
2. Establish a notification procedure within the office as to which managers or owners are to be notified of the receipt any No-Match Letters. Make sure that any such letter is made available immediately to you. In addition, to insure that there is no breakdown in the system due to other demands on your time, make sure the letter is immediately copied to your accountant, bookkeeper, attorney, or other professional members of your team. These letters should be made priority.
3. In a calendar you rely upon for appointments and deadlines, note the date the letter was received and ninety (90) days later to as deadline to reverify employment.
4. Promptly compare the employee’s SSN (you should have a photocopy of the Social Security card in the employee file) with the numbers in the W-4 form submitted to make sure that the No-Match Letter was not the result of a typographical, transcription, or other similar clerical error. If the W-4 *is in error*, then
  - a. Correct the W-4 form and file it with the IRS according to instructions.
  - b. Verify with either the DHS or SSA that the corrections match agency records.
  - c. SEPARATELY, report the correction to the SSA at the address provided for response in the mismatch letter.
  - d. Maintain copies of ALL correspondence submitting and verifying corrected information.
5. If the number on the W-4 form *agrees with the Social Security number* provided by the employee,
  - a. Check the spelling of the name. Computers compare names with SSN, not people. They do not equate Bill with William nor do they know that “Chip” is Charles. Also changes in surnames due to marriage, adoption, or divorce may not be reflected in SSA files.
  - b. Notify the employee immediately, both orally (note it in the file) and in writing that the

SSA has notified you that the number he or she reported does not match the SSA records.

c. Have the employee verify that the information held by the employer is correct. If the information held by the employer is not correct according to the employee records, correct the information in accordance with paragraph.

d. If the employee cannot show that your information is incorrect, then notify the employee that it is his or her responsibility to resolve the dispute with the SSA, not yours.

e. Tell the employee to report immediately to you any response by the SSA.

f. If corrected information is received change your records as per paragraph.

g. REMEMBER: Keep a copy of the letter to the employee and write notes regarding any communication for your records.

6. If the discrepancy is still not resolved. The employer should verify the employee's identity and work authorization as if a new hire. That means filling out a new I-9 Employment Eligibility Verification Form *as if a new hire*.

a. Must be completed within 93 days of receipt of the No-Match Letter

b. No document containing the SSN or Alien Number subject to the discrepancy can be used nor a receipt for an application for a replacement of such a document.

c. No document without a photograph can be used to establish identity.

7. Continue to deduct and pay taxes as you would otherwise do. A No-Match Letter is not notice to stop payroll taxes.

8. If the employee returns with information that could indicate a lack of work authorization (i.e., a new name and/or SSN), then you may need to follow up further to avoid having "constructive knowledge" of the lack of authorization. If a person comes up with an entirely new identity, then the employer must demand an explanation. If the explanation is reasonable, then the employer can accept it and should re-verify the I-9. One such explanation is that the person has gone by one name his or her life, but it does not match the birth certificate of SS records because they did not formally have their name changed.

9. If the employee does not return with corrected information, do not automatically fire the employee or re-verify their authorization to work in the United States. At the end of the year and prior to filing W-4s, remind the employee in writing that you requested him or her to resolve the dispute with the SSA and request an update as to those efforts.

10. Do not accept any document with the challenged SSN until the mismatch is resolved with the SSA.

11. Inform in writing, the SSA all the steps you took to resolve the SSN conflict for each affected employee, including those you no longer employ. Put a copy of this letter in the folder.

Never assume an employee with a reported mismatch is an undocumented alien.

Never fire an employee solely because you received notice of a mismatch.

Never ignore information and common sense when reviewing new information in response to mismatches.

**Immigration law prohibits employers from continuing to employ workers that they know to be**

**undocumented. The employee must be terminated immediately. To do otherwise places the employer at risk of being in violation of the law.**

An employer that receives an SSA nomatch letter and terminates employees without attempting to resolve the mismatches, or who treats employees differently or otherwise acts with the purpose or intent to discriminate based upon national origin or other prohibited characteristics, may be found by OSC to have engaged in unlawful discrimination. However, if an employer follows all of the safe-harbor procedures outlined in DHS's no-match rule but cannot determine that an employee is authorized to work in the United States, and therefore terminates that employee, and if that employer applied the same procedures to all employees referenced in the no-match letter(s) uniformly and without the purpose or intent to discriminate on the basis of actual or perceived citizenship status or national origin, then OSC will not find reasonable cause to believe that the employer has violated section 1324b's antidiscrimination provision, and that employer will not be subject to suit by the United States under that provision.

Department of Homeland Security  
U.S. Citizenship and Immigration Services

**Form I-9, Employment  
Eligibility Verification**

Please read instructions carefully before completing this form. The instructions must be available during completion of this form.

**ANTI-DISCRIMINATION NOTICE:** It is illegal to discriminate against work eligible individuals. Employers CANNOT specify which document(s) they will accept from an employee. The refusal to hire an individual because the documents have a future expiration date may also constitute illegal discrimination.

**Section 1. Employee Information and Verification.** To be completed and signed by employee at the time employment begins.

Print Name: Last	First	Middle Initial	Maiden Name
Address (Street Name and Number)		Apt. #	Date of Birth (month/day/year)
City	State	Zip Code	Social Security #

**I am aware that federal law provides for imprisonment and/or fines for false statements or use of false documents in connection with the completion of this form.**

I attest, under penalty of perjury, that I am (check one of the following):

A citizen or national of the United States

A lawful permanent resident (Alien #) A \_\_\_\_\_

An alien authorized to work until \_\_\_\_\_

(Alien # or Admission #) \_\_\_\_\_

Employee's Signature	Date (month/day/year)
----------------------	-----------------------

**Preparer and/or Translator Certification.** (To be completed and signed if Section 1 is prepared by a person other than the employee.) I attest, under penalty of perjury, that I have assisted in the completion of this form and that to the best of my knowledge the information is true and correct.

Preparer's/Translator's Signature	Print Name
Address (Street Name and Number, City, State, Zip Code)	
Date (month/day/year)	

**Section 2. Employer Review and Verification.** To be completed and signed by employer. Examine one document from List A OR examine one document from List B and one from List C, as listed on the reverse of this form, and record the title, number and expiration date, if any, of the document(s).

List A	OR	List B	AND	List C
Document title: _____		_____		_____
Issuing authority: _____		_____		_____
Document #: _____		_____		_____
Expiration Date (if any): _____		_____		_____
Document #: _____		_____		_____
Expiration Date (if any): _____		_____		_____

**CERTIFICATION - I attest, under penalty of perjury, that I have examined the document(s) presented by the above-named employee, that the above-listed document(s) appear to be genuine and to relate to the employee named, that the employee began employment on (month/day/year) \_\_\_\_\_ and that to the best of my knowledge the employee is eligible to work in the United States. (State employment agencies may omit the date the employee began employment.)**

Signature of Employer or Authorized Representative	Print Name	Title
Business or Organization Name and Address (Street Name and Number, City, State, Zip Code)		Date (month/day/year)

**Section 3. Updating and Reverification.** To be completed and signed by employer.

A. New Name (if applicable)	B. Date of Rehire (month/day/year) (if applicable)
-----------------------------	--

C. If employee's previous grant of work authorization has expired, provide the information below for the document that establishes current employment eligibility.

Document Title: \_\_\_\_\_ Document #: \_\_\_\_\_ Expiration Date (if any): \_\_\_\_\_

**I attest, under penalty of perjury, that to the best of my knowledge, this employee is eligible to work in the United States, and if the employee presented document(s), the document(s) I have examined appear to be genuine and to relate to the individual.**

Signature of Employer or Authorized Representative	Date (month/day/year)
--	-----------------------

**LISTS OF ACCEPTABLE DOCUMENTS**

LIST A Documents that Establish Both Identity and Employment Eligibility	OR	LIST B Documents that Establish Identity	AND	LIST C Documents that Establish Employment Eligibility
1. U.S. Passport (unexpired or expired)		1. Driver's license or ID card issued by a state or outlying possession of the United States provided it contains a photograph or information such as name, date of birth, gender, height, eye color and address		1. U.S. Social Security card issued by the Social Security Administration <i>(other than a card stating it is not valid for employment)</i>
2. Permanent Resident Card or Alien Registration Receipt Card (Form I-551)		2. ID card issued by federal, state or local government agencies or entities, provided it contains a photograph or information such as name, date of birth, gender, height, eye color and address		2. Certification of Birth Abroad issued by the Department of State <i>(Form FS-545 or Form DS-1350)</i>
3. An unexpired foreign passport with a temporary I-551 stamp		3. School ID card with a photograph		3. Original or certified copy of a birth certificate issued by a state, county, municipal authority or outlying possession of the United States bearing an official seal
4. An unexpired Employment Authorization Document that contains a photograph (Form I-766, I-688, I-688A, I-688B)		4. Voter's registration card		4. Native American tribal document
		5. U.S. Military card or draft record		5. U.S. Citizen ID Card <i>(Form I-197)</i>
5. An unexpired foreign passport with an unexpired Arrival-Departure Record, Form I-94, bearing the same name as the passport and containing an endorsement of the alien's nonimmigrant status, if that status authorizes the alien to work for the employer		6. Military dependent's ID card		6. ID Card for use of Resident Citizen in the United States <i>(Form I-179)</i>
		7. U.S. Coast Guard Merchant Mariner Card		
		8. Native American tribal document		7. Unexpired employment authorization document issued by DHS <i>(other than those listed under List A)</i>
	9. Driver's license issued by a Canadian government authority			
		<b>For persons under age 18 who are unable to present a document listed above:</b>		
		10. School record or report card		
		11. Clinic, doctor or hospital record		
		12. Day-care or nursery school record		

**Illustrations of many of these documents appear in Part 8 of the Handbook for Employers (M-274)**

**Instrucciones****Lea cuidadosamente las instrucciones antes de llenar este formulario. (Para uso únicamente en Puerto Rico.)**

**Notificación Anti-Discriminación.** Es ilegal discriminar a cualquier individuo (con excepción de un extranjero no autorizado a trabajar en los E.U.A.) al contratar, desempear, reclutar o contratar por honorarios debido al origen del individuo o su ciudadanía. Es ilegal discriminar a cualquier individuo elegible para trabajar. Los empleadores **NO PUEDEN** especificar que documento(s) aceptarán de un empleado. El negarse a emplear a un individuo porque la fecha de vencimiento de los documentos presentados está cercana puede también constituirse como una discriminación ilegal.

**¿Cuál es el propósito de este formulario?**

El propósito de este formulario es documentar que cada empleado nuevo (ciudadano o no ciudadano) contratado después del 6 de noviembre de 1986 está autorizado a trabajar en los Estados Unidos.

**¿Cuándo debe ser utilizado el Formulario I-9?**

Todos los empleados, ciudadanos y no ciudadanos, contratados después del 6 de noviembre de 1986 y que estén trabajando en los Estados Unidos deben llenar el Formulario I-9.

**Como Llenar el Formulario I-9**

**Sección 1, Empleado:** Esta parte del formulario debe llenarse en el momento de la contratación, que generalmente es el inicio del empleo. Proveer el número de Seguro Social es voluntario, a excepción de aquellos empleados que han sido contratados por empleadores que participan en el Programa Electrónico de Verificación de la Elegibilidad de Empleo de USCIS. **El empleador debe asegurarse que la Sección 1 se llene puntual y correctamente.**

**Certificación del Traductor o Tercero.** La certificación del traductor o tercero debe llenarse si la **Sección 1** es preparada por cualquier persona que no sea el empleado. Un traductor o tercero sólo puede utilizarse cuando el empleado no pueda llenar la **Sección 1** por sí mismo. Sin embargo, el empleado debe firmar la **Sección 1** personalmente.

**Sección 2, Empleador:** Con la finalidad de llenar este formulario, el término "empleador" se refiere a todos los empleadores incluyendo los reclutadores y los contratistas por honorarios tales como las asociaciones agrícolas, empleadores agrícolas o los contratistas de trabajo agrícola.

Los empleadores deben llenar la **Sección 2** examinando las pruebas de identidad y elegibilidad de empleo dentro de los tres (3) días hábiles a partir de la fecha del inicio de empleo. Si el empleado está autorizado para trabajar, pero no puede presentar los documentos requeridos dentro de los tres (3) días hábiles, debe presentar un recibo de esta solicitud dentro de tres (3) días

hábiles, y los documentos requeridos en un periodo de noventa (90) días. Sin embargo, si los empleadores contratan a individuos para trabajar por menos de 3 días hábiles, debe llenarse la **Sección 2** en el momento en el que se inicie el empleo. **Los empleadores deben anotar:**

1. Título del documento.
2. Autoridad que expide el documento.
3. Número de documento.
4. Fecha de vencimiento, si la hay; y
5. Fecha de comienzo del empleo.

El empleador debe firmar y colocar la fecha de la certificación. El empleado debe presentar sus documentos originales. El empleador puede, aunque no está obligado, a fotocopiar los documentos presentados. La(s) fotocopia(s) sólo puede(n) utilizarse para la verificación del proceso y deben guardarse con el Formulario I-9. **Sin embargo, los empleadores son los responsables de llenar y guardar el Formulario I-9.**

**Sección 3, Actualización y nueva verificación:** Los empleadores deben llenar la **Sección 3** cuando se esté actualizando y, o verificando el Formulario I-9. Los empleadores deben verificar de nuevo la elegibilidad de empleo de los empleados para trabajar antes de la fecha de vencimiento anotada en la **Sección 1**. Los empleadores **NO PUEDEN** especificar que documento(s) aceptarán del empleado:

- A. Si el nombre de un empleado ha cambiado en el momento en que este formulario está siendo actualizado o que se realiza la nueva verificación, llene la casilla A.
- B. Si un empleado es contratado nuevamente dentro de tres (3) años de la fecha original del formulario, asimismo el empleado sigue siendo elegible para ser contratado bajo las mismas condiciones previamente señaladas en este formulario (actualización), llene la casilla B y la casilla de la firma.
- C. Si un empleado es contratado nuevamente dentro de tres (3) años de la fecha original de este formulario y la autorización del empleador ha expirado o si la autorización del empleador actual está por vencer (actualización), llene la casilla B y:
  1. Compruebe que cualquier documento que refleje que el empleado está autorizado para trabajar en los E.U.A. (Ver lista A o C);
  2. Anote el título del documento, número del documento y la fecha de vencimiento (si la hay) en la casilla C, y
  3. Llene la casilla de la firma.

### ¿Cuál es el cargo por tramitación?

No hay ningún cargo por concepto de tramitación del Formulario I-9. Este formulario no es tramitado por la USCIS o por ninguna otra agencia del gobierno. El empleador debe guardar el Formulario I-9 y tenerlo disponible para que pueda ser inspeccionado por funcionarios del gobierno de los E.U.A., como especifica el Aviso de la Ley de Privacidad más adelante.

### Formularios e Información de USCIS

Para encargar formularios, por favor llame al **1-800-870-3676**. Si desea conseguir información sobre los formularios de USCIS o sobre las leyes migratorias, procedimientos y normas de inmigración, llame a nuestro Centro de Servicio Nacional al Cliente al **1-800-375-5283** o visite nuestra página web: [www.uscis.gov](http://www.uscis.gov).

### Fotocopia y Conservación del Formulario I-9

Una copia en blanco del Formulario I-9 puede ser reproducida, siempre y cuando ambos lados sean copiados. Las instrucciones deben estar disponibles a todo empleado que llene este formulario. Los empleadores deben conservar los formularios I-9 completos por tres (3) años después de la fecha inicial de empleo o un año después de la fecha en que el empleo termine, lo que sea más tarde.

El Formulario I-9 puede ser firmado y guardado electrónicamente, según lo autorizado en la reglamentación 8 CFR § 274a.2 del Departamento de Seguridad Nacional.

### Aviso de la Ley de Privacidad

La autoridad que recopila esta información es la Ley de Reforma y Control de Inmigración de 1986, Pub. L. 99-603 (8 USC 1324a).

Esta información es para que los empleadores verifiquen la elegibilidad de los individuos a contratar para evitar contrataciones ilícitas, reclutamientos o contratados por honorarios, de extranjeros no autorizados a trabajar en los Estados Unidos.

Esta información será usada por los empleadores como base de su registro para determinar la elegibilidad de un empleado para trabajar en los Estados Unidos. El formulario será guardado por el empleador y se hará disponible para la inspección de oficiales del Departamento de Inmigración y Aduanas de los E.U.A., el Departamento de Trabajo y la Oficina del Consejo para Inmigración y Prácticas de Empleo Injustas.

La aportación de la información requerida en este formulario es voluntaria. Sin embargo, un individuo no puede empezar su empleo sin antes llenar este formulario, ya que el empleador está sujeto a sanciones civiles o criminales si no cumple con la Ley de Control y Reforma de Inmigración de 1986.

### Ley de Reducción de Trámites

Intentamos crear formularios e instrucciones que sean precisos, fáciles de entender y que le impongan la menor carga posible cuando nos provee información. A menudo esto es difícil porque algunas leyes de inmigración son muy complejas. Por consiguiente, la carga de trámites para la recopilación de información es calculada de la siguiente manera: 1) informarse acerca de este formulario y como llenar el formulario 10 minutos; 2) juntar y archivar (registros) el formulario, 2 minutos, lo cual da un promedio de 15 minutos por respuesta. Si usted tiene algún comentario acerca de precisión de esta estimación o sugerencias para hacer este formulario más simple, puede escribir a: U.S. Citizenship and Immigration Services, Regulatory Management Division, 111 Massachusetts Avenue, N.W., 3rd Floor, Suite 3008, Washington, DC 20529. OMB No. 1615-0047.

Department of Homeland Security  
U.S. Citizenship and Immigration Services

**Form I-9, Employment  
Eligibility Verification**

Por favor, lea cuidadosamente las instrucciones antes de llenar este formulario. Las instrucciones deben estar disponibles cuando se llene este documento.

**AVISO ANTI-DISCRIMINACIÓN:** Es ilegal discriminar a cualquier individuo elegible para trabajar. Los empleadores **NO PUEDEN** especificar qué documento(s) aceptarán de un empleado. La negativa a emplear a una persona debido a una fecha futura de vencimiento de los documentos presentados puede constituir discriminación ilegal.

**Sección 1. Información y Verificación del Empleado.** El formulario debe ser llenado y firmado por el empleado en el momento en el que comience a trabajar.

Nombre en Letras de Imprenta: Apellido	Nombre	Inicial del Segundo Nombre	Nombre de Soltero(a)
Dirección (nombre y número de la calle)		Nº de Apto.	Fecha de nacimiento (mes/día/año)
Ciudad	Estado	Código Postal	Nº de Seguro Social
Estoy informado que la ley Federal estipula el encarcelamiento y/o la sanción por declaraciones falsas o por el uso de documentos falsos al llenar este formulario.	Certifico, bajo pena de perjurio, que soy (marque uno de los siguientes):		
	<input type="checkbox"/> Ciudadano o natural de los Estados Unidos <input type="checkbox"/> Residente legal permanente (Nº de Extranjero) A _____ <input type="checkbox"/> Extranjero autorizado a trabajar hasta el _____ (Nº de Extranjero o Nº de Admisión)		
Firma del empleado			Fecha (mes/día/año)

**Certificación del traductor y, o tercero.** (Se debe llenar y firmar si la Sección 1 la llena cualquier persona que no sea el empleado.) Certifico, bajo pena de perjurio, que he ayudado a llenar este formulario y que según mi entender, la información es verdadera y correcta.

Firma del Traductor o Tercero	Nombre y Apellido (en imprenta)
Dirección: (Nombre y Número de la Calle, Ciudad, Estado, Código Postal)	Fecha (mes/día/año)

**Sección 2. Revisión y Verificación del Empleador.** Se debe llenar y firmar por el empleador. Verifique un documento de la lista A o un documento de la lista B y uno de la lista C, tal y como figura en la parte posterior de esta página, y anote el título, número y fecha de vencimiento, si hay alguna, del documento.

	Lista A	O	Lista B	Y	Lista C
Título del Documento:	_____	_____	_____	_____	_____
Autoridad que Emite el Documento:	_____	_____	_____	_____	_____
Nº de Documento:	_____	_____	_____	_____	_____
Fecha de Vencimiento (si la hay):	_____	_____	_____	_____	_____
Nº de Documento:	_____	_____	_____	_____	_____
Fecha de Vencimiento (de ser el caso):	_____	_____	_____	_____	_____

**Certificación - Certifico, bajo pena de perjurio, que he verificado los documentos presentados por el empleado nombrado anteriormente; los documentos en la lista anterior aparentan ser genuinos y son referentes al empleado nombrado. La persona antes mencionada fue empleada (mes/día/año) \_\_\_\_\_ y a mi mejor entender declaro que el empleado es elegible para trabajar en los E.U.A. (Las agencias de empleo del estado pueden omitir la fecha en la que el empleado fue contratado.)**

Firma del Empleado o el Representante Autorizado	Nombre y Apellido (en letra de imprenta)	Título
Nombre y Dirección de la Organización o Compañía (Nombre y Número de la Calle, Ciudad, Estado, Código Postal)		Fecha (mes/día/año)

**Sección 3. Actualización y Nueva Verificación.** Se debe llenar y firmar por el empleador.

A. Nombre (de ser el caso)	B. Fecha de re-contratación (mes/día/año) (de ser el caso)
C. Si la autorización de trabajo previa de su empleador ha expirado, proporcione la información actual en la que indique la elegibilidad actual para trabajar.	
Título de Documento: _____ Nº de Documento: _____ Fecha de Vencimiento (si la hay): _____	

**Certifico, bajo pena de perjurio, con mi mejor conocimiento que este empleado se encuentra apto(a) para trabajar en los E.U.A. En caso de que el empleado haya presentado documentos, los documentos que he revisado aparentan ser genuinos y referentes al empleado.**

Firma del Empleado o Representante Autorizado	Fecha (mes/día/año)
---	---------------------

**LISTAS DE DOCUMENTOS ACEPTABLES**

<b>LISTA A</b> Documentos que Establecen Ambas la Identidad y Elegibilidad Para Trabajar	<b>LISTA B</b> Documentos que Establecen la Identidad	<b>LISTA C</b> Documentos que Establecen la Elegibilidad para el Empleo
<b>O</b>	<b>Y</b>	
1. Pasaporte Estadounidense (vigente o vencido)	1. Licencia de conducir o Tarjeta de Identificación (ID) emitida por el estado o territorio de los Estados Unidos si contienen fotografía o el nombre, fecha de nacimiento, género, altura, color de ojos y dirección	1. Tarjeta de Seguro Social de los Estados Unidos emitida por la Administración de Seguro Social (con excepción de una tarjeta que indique que no se encuentra apto(a) para trabajar)
2. Tarjeta de Residencia Permanente o Tarjeta de Registro de Extranjeros (Formulario I-551)	2. Tarjeta de Identificación (ID) emitida por agencias o entidades del gobierno federal, estatal o local o si contiene una fotografía o información tal como el nombre, fecha de nacimiento, sexo, estatura, color de ojos y dirección	2. Partida de nacimiento en el extranjero emitida por el Departamento de Estado (Formulario FS-545 o Formulario DS-1350)
3. Pasaporte extranjero vigente con un timbre temporal I-551	3. Identificación estudiantil con fotografía	3. Una copia original o certificada de la partida de nacimiento emitida por el estado, condado, autoridad municipal o territorio de los Estados Unidos con sello oficial
4. Tarjeta de Autorización de Empleo vigente con fotografía (Formulario I-766, I-688, I-688A, I-688B)	4. Tarjeta de registro de votante	4. Documento tribal de Nativo-Americano
	5. Tarjeta Militar de los Estados Unidos o tarjeta del servicio militar	5. Tarjeta de Identificación de Ciudadano(a) Estadounidense (Formulario I-197)
5. Pasaporte extranjero vigente con Registro de Entrada y Salida Vigente, Formulario I-94, llevando el mismo nombre que figura en el pasaporte y conteniendo una certificación del estado no inmigrante del extranjero, si ese estado autoriza a el extranjero a trabajar para el empleador	6. Tarjeta Militar de Identificación de dependientes	6. Tarjeta emitida para el uso de Ciudadano Residente en los Estados Unidos (Formulario I-179)
	7. Tarjeta de Marino Mercante de la Guardia Costera Estadounidense	
	8. Documento tribal de Nativo-Americano	7. Autorización de Empleo vigente emitida por DHS (que no sea una de las de la lista A)
9. Licencia de conducir emitida por el gobierno canadiense		
	<b>Para personas menores de 18 años de edad que no puedan presentar los documentos en la lista anterior:</b>	
	10. Expediente académico o tarjeta de calificaciones	
	11. Informe médico, de clínica u hospital	
	12. Registro de guardería	

**En la parte 8 del Manual para Empleadores (M-274) encontrará ejemplos de muchos de estos documentos.**

# Recognizing Stress, Anger, Depression, and Suicidal Thinking and Knowing What to Do Next<sup>1</sup>

Robert J. Fetsch  
Extension Specialist & Professor  
Department of Human Development  
Colorado State University  
Fort Collins, CO 80523-1570  
[fetsch@cahs.colostate.edu](mailto:fetsch@cahs.colostate.edu)  
970-491-5648 (O); 970-491-7975 (fax)

## Introduction

Contrary to the myth of idyllic scenes of farm and ranch life, farm and ranch families have lots to be stressed about. Economic and market conditions change regularly, so profits are uncertain. Furthermore the prices that farmers and ranchers have to pay for their inputs (e.g. gasoline, diesel, fertilizer, equipment, feed, seed, etc.) as well as the prices they get for their outputs (milk, grain, hay, beef, lambs, chickens, pigs, eggs, etc.) are mostly out of their control as is the weather on which they depend for abundant rain and sunshine. Prices are usually set by others, so their control over both what they pay for their inputs and what they receive for their outputs is outside their control, which contributes to feelings of powerlessness and leads to high stress levels.

## Farm/Ranch Stress

Farming is one of the top 12 high stress occupations. The National Institute for Occupational Safety and Health studied 130 occupations and examined the incidence of stress-related diseases (coronary heart and artery disease, hypertension, ulcers, and nervous disorders). They examined more than 22,000 Tennessee workers' health records, death certificates, hospital admissions, and mental health center admissions and found that farm owners were among 12 categories of workers that displayed high incidence of stress-related illnesses. When the death certificates were analyzed alone, farm owners were second only to laborers in the rate of death for stress-related diseases.

***What were the top stressors for farmers?*** In a study of close to 1,000 New Zealand dairy farmers, the highest levels of stress were reported for time pressures, machinery failures, weather, and government policies. A study of 1,015 individuals from 669 New Zealand farms reported that their leading stressors were "increased work load at peak times," "dealing with workers' compensation," "bad weather," and "complying with health and safety legislation". In a study of 500 farmers in England and Wales, the major stressors were government regulations, paperwork, financial difficulties, and health related problems. Other studies identified the top stressors as economic factors, work overload, relationship issues, coping with new legislation, excessive paperwork, and media criticism. A study of 1,343 Iowa farm residents identified their top ten stressors to include death of a spouse, death of a child, disabling injury of a family member, disabling injury to oneself, foreclosure on a mortgage or loan, divorce, machinery breakdown during harvest, loss of crop to

---

<sup>1</sup> This is to acknowledge and express appreciation for the literature review provided by Christina L. Collins, Graduate Student, Department of Human Development & Family Studies, Colorado State University.

weather, loss of crop to pests or disease, and severe weather conditions. One of the most stressful intergenerational farming/ranching issues is the transfer of the family ranch/farm from one generation to the next and the need to keep it stable and operating in order to sustain profitability.

***Among farmers, who experiences more stress?*** Among two-generation farm families in which both parents and their adult children were actively involved in operating the farm or ranch, researchers found that the younger generation experienced more stress, less perceived social support, and less occupational satisfaction than the older generation. The authors inferred that feelings of powerlessness from working on a multigenerational farm where they had little power and more financial pressure and debt load may contribute to higher stress levels among younger farmers. The most frequently occurring stressor for two-generation farm families in Iowa was living with “tight money”. For sons- and daughters-in-law, another frequently reported stressor was not being on one’s own. For mothers and fathers, the most frequently reported stressor was taking responsibility for risks and disagreements over spending. A frequently reported stressor for daughters-in-law and mothers was “not being a part of the operation.” A study of 242 senior generation farmers and 239 junior generation farmers found that: “...neither generation is happy with the communication in their two-generation farm family. Items such as handling arguments, fair criticism and family problems were ranked low by both groups”. In another study, daughters-in-law were reported to experience the highest level of stress within family units with a negative relationship with the parents-in-law exacerbating her stress levels. Stress levels were found to be higher for mixed type operations (e.g. livestock and grain) than for grain farmers. Overall, the integrated nature of working, playing, and living side by side, day after day seems to lead to stressors that may be unique among farm and ranch families.

***Do farmers and ranchers experience significantly higher levels of stress than does the general population?*** Research with more than 22,000 Tennessee workers, as reported earlier, indicated that farming is one of the top 12 (of 130) high stress occupations. In a study of 303 people in the United Kingdom, farmers scored significantly higher than the general population on measures of stress. More research is needed comparing the stress levels of farmers and ranchers with the general population.

### **Ranch/Farm Anger**

There is a dearth of research comparing the levels of anger between farming and non-farming populations. Only one published study was found that reported such a comparison. It examined the anger levels of 323 parents who participated in an anger management parenting program. Participants were divided into three groups: 1) people who lived on a farm or ranch or rural setting; 2) people who lived in a small town; and 3) people who lived in a small city or metropolis. The research compared the three groups’ average scores on self-reported anger levels, anger expression and control, verbal and physical aggression, and family violence. There was no statistically significant difference between groups on any variable, except for state anger, which refers to the intensity of one’s anger at a particular moment. Those parents who lived on a farm or ranch or in a rural setting reported significantly lower levels of state anger than parents who lived in a small city or metropolis. More research is needed comparing anger levels of farmers/ranchers with those of non-farm populations.

## **Farm/Ranch Depression**

Many ranchers and farmers struggle with depression. Nevertheless, it is still not clear whether they experience lower or higher levels of depression and other mental health problems than the general population.

Some researchers found lower or inconsistent levels of depression in a Colorado sample of farm residents, although those who were female, in poor physical health, and unmarried or who were younger tended to be more depressed than older farmers. Other researchers also found lower levels of general psychiatric morbidity than the general population in Great Britain although they were more likely to think that life was not worth living. Still other researchers found inconsistent patterns of psychiatric morbidity and depression or that Australian farmers did not experience higher rates of mental health problems than non-farmers.

Other researchers found higher levels of depression in farmers and ranchers than the general population. Researchers studied a sample of 17,000 people in Norway and found higher levels of anxiety and depression among full-time, part-time, and all farmers than among nonfarm men and women. They speculated that the higher levels of depression and anxiety may be due to longer work hours, physically harder work, and lower income than non-farmers. Other researchers found that high levels of occupational stress among British farmers may contribute to elevated depression and anxiety levels. Other researchers found a correlation between exposure to pesticides and high levels of depression among Colorado farmers and ranchers. Research with North Dakota farmers found that their depression levels were almost twice that found in past research with other rural populations. North Dakota farmers were least likely to seek help from mental health professionals or clergy and were resistant to expressing negative emotions to others. Still others found that Iowa farmers were 1.74 times more likely to exhibit signs of depression than Colorado farmers. Iowa farm men who experienced five stressors within the previous year were more likely to experience depression if they had: lost something of sentimental value; experienced substantial income decline; gone deeply into debt; faced legal problems; or experienced an increase in health problems. Researchers found that Virginia farmers' depression rates were 1.7 times the rate of depression among the American working population, 1.4 times higher than that of Iowa farmers, and 2.3 times higher than those of Colorado farmers and ranchers. The higher levels of depression in Virginia may be attributed to lack of access to adequate medical help and having an older sample.

## **Ranch/Farm Suicide Rates**

While some researchers found lower and others found higher depression levels among farm residents, there is extensive research evidence that farmers and ranchers have high rates of suicide. Higher rates of suicide in farmers and ranchers have been reported in the United Kingdom, Australia, Canada, Scotland, and the United States. In Colorado, historically, the leading external causes of death on farms and ranches have been: 1) suicide; 2) animal incidents; and 3) tractor/machinery rollovers (T. Daniels, personal communication, August 22, 2000). Between 2000 and 2004, the external cause of death for one out of five Colorado ranchers and farmers was suicide (K. Bol, e-mail communication, October 20, 2005 and Statistics Section of Colorado Department of Health and Environment). In Colorado three out of four suicides are committed by men. In China, two out of three suicides are committed by women.

In the United States, it has been reported that farm women, children, adolescents, and farm laborers were at a low risk of suicide, but that farmers and ranchers were 1.5-2.0 times more likely to commit suicide than other adult men. They found a crude death rate, which does not adjust for age, of all full-time farmers in the sample to be 48.1 per 100,000. Researchers in Kentucky also reported a crude death rate of 48.1 per 100,000 in a sample of farmers. These suicide rates are much higher than both the U.S. suicide rate of 11.0 per 100,000 and the Colorado suicide rate of 17.1 per 100,000 in 2005. The suicide rate for rural men is on average twice that of their urban counterparts after controlling for divorce and ethnicity, and the rate is increasing over time.

The most common suicide method was firearms, in the United Kingdom, Australia, Scotland, and the United States.

***Why do farmers and ranchers commit suicide at higher rates than the general population?*** No clear answer was found in the literature. Researchers found no support for the sometimes hypothesized relationship between farming residents and increased levels of mental health problems. They identified the following difficulties that farmers and ranchers reported facing when seeking mental health assistance: the demands of family farms; the culture of farming communities; and the shortage of health care professionals with rural farming communities. Other researchers used the psychological autopsies of 84 farmers who died between 1991 and 1994 in England and Wales and hypothesized the following possible causes of high suicide rates: high accessibility to firearms; occupational stress; financial difficulties; and family problems. They also found that retirement seems to be a trying transition for farmers in the sample. Other researchers found no significant seasonal variation of suicide in their sample of United Kingdom farmers. Interestingly, a group of researchers reported that upon the passage of legislation in 1989 to further regulate firearm ownership, registration, and storage in England and Wales, there was a reduction in firearm deaths and a reduction in farm suicides. By the end of the study, hanging was more frequent than firearms as cause of death.

In summary, in the U.S. increased access to firearms may account for elevated levels of completed suicide, but pesticides, financial loss, and barriers to seeking mental health treatment may be related as well. However, considering some researchers' findings that farmers and ranchers experience fewer mental health problems than the general population, the link between farmers and ranchers and an elevated risk for suicide is not well understood and warrants further research.

### **What to Do Next?**

The first thing to do is to recognize signs of farm and ranch stress in a friend, neighbor, spouse, family member, or oneself. See the Appendix below. Make copies of the Appendix and hand it out to groups and individuals so they too recognize the signs of trouble. If you are concerned about someone, make note of signs of chronic, prolonged stress that you notice in the person. Take note of signs of depression that you observe in them. Pay special attention to signs of suicidal intent or thinking. If you suspect that someone may be depressed and suicidal, prepare yourself with the next steps before you visit with them.

Second, take action. Find out what resources are available in your area to assist folks with high levels of stress, anger, depression, and suicidal thinking. They may be few and far between in many rural settings, but almost always there are at least one or two marriage and family therapists, psychologists, social workers, mental health counselors, clergy, or guidance counselors within

driving distance. TherapistLocator.net is a good resource for finding marriage and family therapists in your area at <http://therapistlocator.net>. If necessary, you can always call 1-800-SUICIDE which is a suicide prevention, crisis intervention, and referral telephone number that offers a live human being to listen well to depressed and suicidal callers and refer them to local resources 24 hours per day.

Third, connect. Make an excuse to stop by and visit with the person you are concerned about. Sit down with them face-to-face. Say something like: “Joe, how long have we known each other—22 years? We’ve been friends and neighbors for a long time, and I have to say that I am worried about you. I see your sad face. I hear how hopeless you sound. When you say, ‘I’m calling it quits; let’s have a last cigarette together,’ I am afraid. I am afraid that you’re thinking about hurting yourself. Are you? ... Tell me about it. I’ve got all the time in the world. Tell me what’s going on.” Then listen. Do not moralize. Don’t say, “Cowboy it up, Joe!” Don’t say, “You’ve got to look at the bright side.” Those comments may set up roadblocks so that Joe will stop talking with you. Instead, paraphrase what you are hearing. “Sounds like things have gotten so bad financially that you don’t know what to do next. ... And you’re thinking that maybe your family would be better off without you. Am I getting it right what’s going on for you?”

If you recognize signs of depression and suicidal thinking in a family member, friend, or yourself, call 1-800-SUICIDE for help and local resources. Use “How to Refer a Person for Help” in the Appendix. Connect Joe with a professional. You can always call 911 or transport your friend to an emergency room at the nearest hospital.

For additional trustworthy information, call Colorado State University Extension (970-491-6281) or call their “Other Bookstore” (970-491-6198), <http://www.ext.colostate.edu/PUBS/CONSUMER/pubcons.html>.

- Managing stress during tough times (no. 10.255)
- Making decisions and coping well with drought (no. 10.256)
- Farming and ranching: Health hazard or opportunity? (no. 10.201)
- Ranching and farming with family members (no. 10.217)
- Youth and suicide (no. 10.213)
- Dealing with our anger (no. 10.236)
- Dealing with others’ anger (no. 10.237)
- Dealing with couples’ anger (no. 10.238)

For more trustworthy information, contact the University of Wyoming, <http://agecon.uwyo.edu/riskmgmt/humanrisk/HUMANFamily.htm>.

References are available from the author upon request.

## APPENDIX

### Farm and Ranch Family Stress and Depression: A Checklist and Guide for Making Referrals

**Roger T. Williams**  
Professional Development & Applied Studies  
University of Wisconsin-Madison

**Robert J. Fetsch**  
Human Development & Family Studies  
Colorado State University

#### SIGNS OF FARM AND RANCH STRESS

The last few years have been difficult for farm and ranch families. Many are experiencing financial and emotional stress as a result. There are several signs or symptoms when a farm family may be in need of help. These are signs that can be observed by friends, extended family members, neighbors, milk haulers, veterinarians, clergy persons, school personnel or health and human service workers. These signs include:

- **Change in routines.** The rancher or ranch family stops attending church, drops out of 4-H, Home-makers or other groups, or no longer stops in at the local coffee shop or feed mill.
  - **Increase in illness.** Farmers or farm family members may experience more upper respiratory illnesses (colds, flu) or other chronic conditions (aches, pains, persistent cough).
  - **Appearance of farmstead declines.** The farm family no longer takes pride in the way farm buildings and grounds appear, or no longer has the time to do maintenance work.
- **Care of livestock declines.** Cattle may not be cared for in the usual way; they may lose condition, appear gaunt or show signs of neglect or physical abuse.
  - **Increase in farm or ranch accidents.** The risk of farm accidents increases due to fatigue or loss of ability to concentrate; children may be at risk if there isn't adequate childcare.
  - **Children show signs of stress.** Farm and ranch children may act out, decline in academic performance or be increasingly absent from school; they may also show signs of physical abuse or neglect.

#### SIGNS OF CHRONIC, PROLONGED STRESS

When farm and ranch families are stressed out for long periods of time – chronic, prolonged stress – they may experience a number of signs and symptoms. Watch for the following effects in farm families you see on a day-to-day basis:

<b>Physical</b>	<b>Emotional</b>	<b>Behavioral</b>
Headaches	Sadness	Irritability
Ulcers	Depression	Backbiting
Backaches	Bitterness	Acting Out
Eating Irregularities	Anger	Withdrawal
Sleep Disturbances	Anxiety	Passive-Aggressiveness
Frequent Sickness	Loss of Spirit	Alcoholism
Exhaustion	Loss of Humor	Violence

### Cognitive

Memory Loss  
Lack of Concentration  
Inability to Make Decisions

### Self-Esteem

“I’m a failure.”  
“I blew it.”  
“Why can’t I...?”

### SIGNS OF DEPRESSION OR SUICIDAL INTENT

The greater the number of signs or symptoms a ranch or farm family is experiencing, the greater your concern should be. In addition, if family members are exhibiting the following signs of depression or suicidal intent, it is important that you connect them with professional help as soon as possible. All cries for help should be taken seriously.

#### Signs of Depression

**Appearance:** Sad face, slow movements, unkempt look.

**Unhappy feelings:** Feeling sad, hopeless, discouraged, and listless.

**Negative thoughts:** “I’m a failure;” “I’m no good,” “No one cares.”

**Reduced activity and pleasure in usual activities:** “Doing anything is just too much of an effort.”

**People problems:** “I don’t want anyone to see me,” “I feel so lonely.”

**Physical problems:** Sleeping problems, decreased sexual interest, headaches.

**Guilt and low self esteem:** “It’s all my fault,” “I should be punished.”

#### Signs of Suicidal Intent

**Anxiety or depression:** Severe, intense feelings of anxiety or depression.

**Withdrawal or isolation:** Withdrawn, alone, lack of friends and supports.

**Helpless and hopeless:** Sense of complete powerlessness, a hopeless feeling.

**Alcohol abuse:** There is often a link between alcoholism and suicide.

**Previous suicidal attempts:** May have been previous attempts of low to high lethality.

**Suicidal plan:** Frequent or constant thoughts with a specific plan in mind.

**Cries for help:** Making a will, giving possessions away, making statements such as “I’m calling it quits,” or “Maybe my family would be better off without me.”

### HOW TO REFER A PERSON FOR HELP

1. Beware of the agencies and resources available you your community—what serices they offer and what their limitations are.
2. Listen for signs and symptoms that the person or family needs help which you can’t provide, i.e., financial, legal or personal counseling.
3. Assess what agency or community resources would be most appropriate to address the person’s (or family’s) problems.
4. Discuss the referral with the person or family (It sounds/looks like you are feeling \_\_\_\_\_. I think \_\_\_\_\_ could help you deal with your situation.”)
5. Explore the individual’s or family’s willingness to initiate contact with the community resource (“How do you feel about seeking help from this person/agency?”).

6. Where the person or family is unwilling to take the initiative or where there is some danger if action is not taken, you should take the initiative:
  - a. Call the agency and ask to speak to the intake worker (if there is one).
  - b. Identify yourself and your relationship with the person or family.
  - c. State what you think the person's or family's needs are (needs immediate protection from suicidal acts, needs an appointment for counseling, needs financial or legal advice).
  - d. Provide the agency with background information (name, address and phone; age and gender; nature of current problem or crisis; any past history you're aware of; further information as called for).
  - e. Ask the agency what follow-up action they will take:
    - \*When will they act on the referral?
    - \*Who will be the person for you to contact later if necessary?
    - \*What will be the cost of the service (flat fee/sliding scale)?
    - \*Do you need to do anything else to complete the referral?
7. Make sure the person or family and the referral agency connect and get together. Make one or more follow-up contacts with the agency if called for by the situation.

# The Future of Ag Biotechnology: Who Prevails?

Terry D. Etherton,  
Department of Dairy and Animal Science  
324 W.L. Henning Building  
The Pennsylvania State University  
University Park, PA 16802  
Phone: 814-863-3665  
FAX: 814-863-6042  
Email: tde@psu.edu

## Introduction

Since the onset of the modern era of biotechnology in 1973, impressive strides have been made in developing new agricultural biotechnologies (reviewed in Metabolic Modifiers, 1994; Etherton et al., 2003). Numerous plant biotechnology products have been developed for production agriculture that have been widely adopted worldwide. They have been widely adopted because of the tremendous benefits they provide. From 1996 to 2007, farmers worldwide have planted more biotech crops every single year. In 2007, for the twelfth consecutive year, the global area of biotech crops continued to soar (James, 2007). In 2007, acreage planted to biotech crops grew by about 12% (30 million acres) – the second highest increase in the last five years – reaching 282.4 million acres.

In 2007, the number of countries planting biotech crops increased to 23, and comprised 12 developing countries and 11 industrial countries; they were, in order of acreage, USA, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Spain, Mexico, Colombia, Chile, France, Honduras, Czech Republic, Portugal, Germany, Slovakia, Romania and Poland (James, 2007). This very high adoption rate by farmers reflects the fact that biotech crops have consistently performed well and delivered significant economic, environmental, health and social benefits to both small and large farmers in developing and industrial countries. These benefits include crops that are more tolerant to the biotic stresses caused by pests, weeds and diseases. In addition, biotech crops have had substantive benefits on the environment by reducing the environmental footprint of agriculture. Progress in developing beneficial traits since the inception of biotech crops includes a significant reduction in pesticides, saving on fossil fuels and decreasing CO<sub>2</sub> emissions through no/less plowing, and conserving soil and moisture by optimizing the practice of no till through application of herbicide tolerance.

The biotechnology products that have been developed and approved for animal agriculture are designed to enhance productivity and *productive efficiency* (feed consumed/unit of output). Biotechnologies that improve productive efficiency will benefit both producers and consumers because feed provision constitutes a major component (about 70%) of farm expenditures. Advances in biotechnology research also have allowed impressive improvements to be made in diagnostic approaches, increasing microbial safety of food, and improvements in animal health (reviewed in Etherton et al., 2003).

The discovery and development of new animal biotechnologies are part of a continuum leading to the commercialization of biotechnology products for agriculture. In order to enter the marketplace, new agricultural biotechnologies are evaluated rigorously by the appropriate federal regulatory

agencies to ensure efficacy, consumer safety, and animal health and well being (FDA, 2008). To benefit agriculture and society, products of biotechnology must be accepted by consumers. Central to consumer acceptance is the need to provide effective population-based education programs to enhance public understanding of the safety and benefits associated with technological advances enabled by agricultural biotechnology.

This brief review addresses the topic of who prevails with respect to the use of production practices and biotech products in animal agriculture. Despite remarkable advances in biotechnology research, and the need for biotech products in agriculture, a public discussion still continues about the need for, and safety of these biotechnologies. The “public discussion” in many instances is an attack on the use of biotechnology in agriculture. These attacks have several common themes – they are characterized by deceptive misinformation campaigns; use of the internet is a core component of these campaigns; they assault the integrity of science, scientists and farmers; they are very well funded; and there is a well-coordinated network of activist groups carrying out these attacks. The most recent estimates indicate that these groups collectively spend in excess of \$500 million per year on their “agenda”!

It is evident that the benefits of investing in discovery research that improves animal agriculture must be championed, and the return on this investment clearly communicated to the public and policy makers. In my opinion, the agricultural community is going to navigate a period over the next few decades during which we will likely witness growing challenges, especially increased regulatory oversight in addition to the misinformation campaigns funded by activist anti-ag groups. For the full benefits of agricultural biotechnology to be realized by society, future regulatory policies and production practices must be guided by the scientific evidence base, not vocal anti-ag activist groups. It is becomingly increasingly evident that the scientific and agricultural communities have not been effective in this “battle” to inform the consumer about the need for, and benefits of biotechnology in agriculture. If this continues, then the issue of who prevails will be guided by the activist groups who are “anti” biotechnology and production agriculture.

### **Food Production: Uses of Biotechnology in Animal Production**

***Metabolic Modifiers.*** In the discussion about who “prevails”, it is important to have a context about the biotechnologies that have developed for animal agriculture, and their benefits. Metabolic modifiers are a group of compounds that modify animal metabolism in specific and directed ways. Metabolic modifiers have the overall effect of improving production, productive efficiency (weight gain or milk yield/unit of feed consumed), improving carcass composition (lean:fat ratio) in growing animals, increasing milk yield in lactating animals, and decreasing animal waste/production unit (reviewed in *Metabolic Modifiers*, 1994).

Two classes of compounds have received major focus - somatotropins (STs) and *β-adrenergic agonists*. The most commonly discussed ST is recombinant bovine somatotropin (rbST), which has been commercially used in the United States since 1994 for administration to lactating dairy cows to increase milk yield (about 10 lbs per cow per day), improve milk/feed, and decrease animal waste (Etherton and Bauman, 1998; Bauman, 1999; Capper et al., 2008).

Supplementing *β-adrenergic agonists* to growing animals improves feed utilization and increases rate of weight gain, and improves carcass leanness and dressing percentage (*Metabolic Modifiers*, 1994).

Research has established that the mode of action involves changes in endocrine and cellular mechanisms (Metabolic Modifiers, 1994). The net effect is that  $\beta$ -adrenergic agonists improve productive efficiency by modifying specific metabolic signals in a coordinated manner to increase nutrient use for lean tissue growth. The  $\beta$ -adrenergic agonist, Ractopamine, has been approved by the FDA for use in growing pigs (Paylean) and beef cattle (Optaflexx).

**Cloning.** Cloning, a term originally used primarily in horticulture to describe asexually produced progeny, means to make a copy of an individual or, in cellular and molecular biology, groups of identical cells, and replicas of DNA and other molecules. For example, monozygotic twins are clones. Animal cloning in the late 1980s resulted from the transfer of nuclei from blastomeres of early cleavage-stage embryos into enucleated oocytes, and cloning of livestock and laboratory animals has resulted from transferring a nucleus from a somatic cell into an oocyte from which the nucleus has been removed (Wilmut et al., 1997; Westhusin et al., 2001).

Somatic cell nuclear transfer also can be used to produce embryonic stem cells, which are undifferentiated, and matched to the recipient for research and therapy that is independent of reproductive cloning of animals. The progeny from cloning using nuclei from either blastomeres or somatic cells are not exact replicas of an individual animal due to cytoplasmic inheritance of mitochondrial DNA from the donor egg, other cytoplasmic factors which may influence "reprogramming" of the genome of the transferred nucleus, and subsequent development of the cloned organism.

Cloning by nuclear transfer from embryonic blastomeres (Willadsen, 1989) or from a differentiated cell of an adult (Wilmut et al., 1997; Polejaeva et al., 2000; Kuhholzer and Prather, 2000) requires that the introduced nucleus be reprogrammed by the cytoplasm of the egg and direct development of a new embryo, which is then transferred to a recipient mother for development to term. The offspring will be identical to their siblings and to the original donor animal in terms of their nuclear DNA, but will differ in their mitochondrial genes; variances in the manner nuclear genes are expressed are also possible. Although *clone* is descriptive for multiple approaches for cloning animals, in this article *clone* is used as a descriptor for somatic cell nuclear transfer.

On January 15, 2008, the Food and Drug Administration (FDA) published the "final" risk assessment (RA) on whether cloning affects food safety or animal health, and whether food products from livestock should be sold for consumption. The report "Animal Cloning – A Risk Assessment" ([http://www.fda.gov/cvm/CloneRiskAssessment\\_Final.htm](http://www.fda.gov/cvm/CloneRiskAssessment_Final.htm)) concluded that meat and milk from clones of cattle, swine, and goats, and the offspring of clones from any species traditionally consumed as food, are as safe to eat as food from conventionally bred animals. Publication of the final version of the FDA Risk Assessment is an important next step in the process that will allow food from cloned animals to enter the food system.

### **A Look to the Future – Who Prevails?**

A "case study" of the battle over animal biotechnology, and who prevails, is the use of rbST in the dairy industry. The benefits of supplementing lactating cows with rbST are well established (reviewed in Etherton and Bauman, 1998; Bauman, 1999). The current "state of affairs" with respect to rbST use in the United States is that the biotechnology is under attack, and many

marketers of fluid milk have labels on the containers that tout the milk is from cows not treated with rbST. The obvious inference is that there is some “problem” with rbST use (which is nonsense), and that “sensible” consumers should avoid rbST. And, by the way, pay more for rbST-free milk. This is remarkably unfortunate since conventional and “rbST-free” milk do not differ compositionally (Vicini et al., 2008), and treatment of cows with rbST does not alter milk levels of the hormone. A detailed history of the attack on rbST, and on producers who use a profitable and safe biotechnology has been chronicled in my blog (see <http://blogs.das.psu.edu/tetherton/>). Inherent to the “attack” on rbST use is that it also represents an attack on the freedom of dairy producers to use a safe and profitable management tool.

The impressive growth in the science of biotechnology, and the many products of biotechnology that have been developed for medical and agricultural application is an impressive achievement. Predicting what scientific discoveries will be made and applied in production agriculture between now and 2050, however, is challenging. Before we in agriculture get carried away anticipating scientific advances in biotechnology over the next 40 years, there are several key issues that must be considered *and* addressed.

***The Challenges.*** First, funding for discovery and applied research in animal agriculture must be increased. Second, innovative scientific discoveries made require a viable private sector to develop and commercialize new products of biotechnology. This is becoming more challenging for a variety of reasons. The process of moving a product through the regulatory approval process is becoming more complex, costly and lengthy. This growing burden makes it challenging for private sector companies to recover their investment costs from product sales. This is particularly important for agricultural biotechnologies where the margins on products are much lower than biomedical biotechnology products (using essentially the same science). Over the past 20 years, a number of companies have withdrawn from developing and commercializing biotechnology products that are not animal health products. This is an enormous problem. What has not been widely discussed is the question: what is the “cost” to society if biotechnological innovation in animal agriculture is hindered or even stopped? There are no good estimates for this, other than it will be enormous, and catastrophically hinder future development of new strategies to feed the World.

Another challenge to commercialization of biotechnology for animal agriculture pertains to the activist groups that are actively advocating that adoption of biotechnology-derived products be halted. In the case of rbST, they have been aggressively pushing the idea that use of an FDA-approved product be banned. The anti-animal ag and anti-biotech activist groups have a combined annual budget of close to \$500 million to spend on efforts designed to influence elected officials and regulators, businesses, as well as consumers about issues such as animal welfare and housing, use of animals for research, animal and plant biotechnology, antibiotic use, BSE/mad cow disease, cloning, rbST, and pesticide use. Moreover, these groups have launched a media attack that claims consumption of food from cloned animals is dangerous, which is nonsense (discussed in detail at Terry Etherton’ Blog on Biotechnology).

***Scaring Consumers.*** A key strategy in the attacks by activist groups is to scare consumers. It is easy to scare the public in a 30 second TV clip; however, it is not possible to educate them about science, agriculture, and biotechnology in 30 seconds. Moreover, this “public discussion” is moving at the

speed of the internet. Sophisticated websites, blogsites, and mass mailings of propaganda and letters by email are all standard tactics used by the Luddites.

Other communication mediums also are used effectively by activist groups. For example, a search of the YouTube website (on January 4, 2009) using the search phrase “PETA” yielded 15,800 video clips! The “Meatrix Videos” are another example of deceptive and inaccurate campaigns that attack animal agriculture. The activist groups who attack and terrorize animal agriculture and conventional agricultural production practices have as their objective to move consumers to a plant-based diet, and end “factory farming” (one of their favorite, deceptive sound bites used to scare consumers). Fear-based and emotional marketing strategies are their standard tactical approach.

A key question: Who is on the other side of this battle? Who is the voice for science, scientists, and production animal agriculture? Certainly, there is no organization or organized effort that is pro-ag biotechnology that has a budget like those of the larger activist groups. This is troublesome, and has the consequent effect that the public is inundated with misinformation about agricultural production practices and the importance of ag biotechnology.

While the “anti’s” assert that advocacy is a core aspect of their mission, it is inaccurate to use advocacy as the descriptor because it implies that you are “for” something. It is abundantly clear that these groups are really “anti-everything.” They embody a “take-away” strategy rather than championing the noble effort to pursue a mission of “adding to” society...of doing something for the greater good of society.

## **Conclusion**

Attacks on production agriculture, best management practices used, and farmers’ freedom to operate and use biotechnology likely will continue in the future. The recent passage of Proposition #2 in California exemplifies this trend. The activist groups that “drive” these attacks are vocal and adept at creating the impression that there are issues when the facts indicate other-wise. It will be crucial that pro-animal agriculture organizations, producer groups, and scientists become the voice of sanity and reason. If we don’t take a proactive approach to this challenge, if we continue to sit on, or close to the sidelines, we may be marginalized in the process that builds the future regulatory environment for developing and applying biotechnologies for animal agriculture, and the use of best-management practices in the United States.

If this happens, we could well witness a substantial core of our food production system move off-shore. Then the issue looms as to whether we can have national security in the absence of food security? This will be a short debate since the answer to this question is obviously no.

With respect to who prevails in the battle for determining whether we “use” safe and effective ag biotechnologies in the future, I believe we in agriculture are at a tenuous time. There are many indicators of the increasing need to develop biotechnologies to feed a growing world (reviewed in Terry Etherton’s Blog on Biotechnology). Yet, there is no pro-ag biotech effort that has thus far proved effective in swaying the public about the need for and value of science for agriculture. To educate the population about science and agriculture is a large, costly and timely process. A large majority of consumers are not well informed about science or production agriculture practices, which creates learning barriers. Furthermore, there is a clear anti-science element that pervades a

significant portion of contemporary print journalism. The marketing tactics used by the organic food sector adds to the confusion. A typical marketing campaign for organic food vendors is to subtly, or not so subtly, infer that the food produced by production agriculture is not as safe or as healthy as their products. To appreciate the scale of these marketing efforts by organic vendors, all one has to do is visit your closest organic grocery store.

In closing, there should be no “public discussion” about the safety and need for ag biotechnologies. Moreover, farmers should have the freedom to use safe approved biotechnologies that improve food production efficiency and provide a fair return on their investment. However, the reality that confronts production agriculture is that there is an active cohort of activist groups who aggressively promote their misleading “propaganda”. The existing and looming challenge for all participants in the food production system who value the development and application of science is to become actively involved in the effort to educate consumers about the importance of biotechnology in food production.

### References

Bauman, D.E. 1999. Bovine somatotropin and lactation: From basic science to commercial application. *Domest. Anim. Endocrinol.* 17:101–116.

Capper, J. L., E. Castañeda-Gutiérrez, R.A. Cady and D.E. Bauman. 2008. The environmental impact of recombinant bovine somatotropin (rbST) use in dairy production. *Proc. Natl. Acad. Sci. USA.* 2008 105:9668-9673.

Etherton, T.D. and D.E. Bauman. 1998. The biology of somatotropin in growth and lactation of domestic animals. *Physiol. Rev.* 78:745–761.

Etherton, T.D., D.E. Bauman, C.W. Beattie, R.D. Bremel, G.L. Cromwell, V. Kapur, G. Varner, M.B. Wheeler and M. Wiedmann. 2003. *Biotechnology in Animal Agriculture: An Overview.* CAST (Council for Agricultural Science and Technology) Issue Paper, No. 23.

Faust, M. 2002. New feeds from genetically modified plants: the U.S. approach to safety for animals and the food chain. *Livestock Prod. Sci.* 74:239–254.

FDA. 2008. Animal Cloning: A Risk Assessment.  
[http://www.fda.gov/cvm/CloneRiskAssessment\\_Final.htm](http://www.fda.gov/cvm/CloneRiskAssessment_Final.htm)

James, C. 2007. *Global Status of Commercialized Biotech/GM Crops: 2007.* International Service for the Acquisition of Agri-biotech Applications. Brief Number 37-2007. ISAAA, Ithaca, New York.

Kuhholzer, B. and R.S. Prather. 2000. Advances in livestock nuclear transfer. *Proc. Soc. Exp. Biol. Med.* 224:240-245.

*Metabolic Modifiers: Effects on Nutrient Requirements of Food-Producing Animals.* 1994. T.D. Etherton (Ed.). Board on Agriculture, National Research Council, National Academy of Science Press, Washington, D.C.

Polegaeva, I.A., S.H. Chen, T.D. Vaught, R.L. Page, J. Mullins, S. Ball, Y. Dai, J. Boone, S. Walker, D.L. Ayares, A. Colman and K.H. Campbell. 2000. Cloned pigs produced by nuclear transfer from adult somatic cells. *Nature*. 407:86-90.

Terry Etherton Blog on Biotechnology. <http://blogs.das.psu.edu/tetherton/>.

Vicini, J., T. Etherton, P. Kris-Etherton, J. Ballam, S. Denham, R. Staub, D. Goldstein, R. Cady, M. McGrath and M. Lucy. 2008. Survey of retail milk composition as affected by label claims regarding farm-management practices. *J. Am. Diet. Assoc.* 108:1198-1203.

Westhusin. M.E., C.R. Long, T. Shin, J.R. Hill, C.R. Looney, J.H. Pryor and J.A. Piedrahita. 2001. Cloning to reproduce desired genotypes. *Theriogenology*. 55:35-49.

Wilmut I., A.E. Schnieke, J. McWhir, A.J. Kind and K.H. Campbell. 1997. Viable offspring derived from fetal and adult mammalian cells. *Nature*. 385:810-813.

Willadsen, S.M. 1989. Cloning of sheep and cow embryos. *Genome*. 31:956-962.



# Transition Management Checklist

M. W. Overton, DVM, MPVM,  
Department of Population Health,  
University of Georgia-College of Veterinary Medicine,  
Athens, GA 30602  
Email: [moverton@uga.edu](mailto:moverton@uga.edu)  
W. Gene Boomer, DVM,  
Manager Field Technical Services,  
Arm & Hammer Animal Nutrition, Visalia, CA  
Patrick J. Gorden, DVM,  
Veterinary Diagnostic & Production Animal Medicine,  
Iowa State University

Many dairy herds today are frustrated by transition management challenges that affect early lactation performance for cows in herds of all sizes. The transition period, which extends from approximately three weeks prior to calving until approximately 3 weeks post-calving, is a high-risk time in a cow's life. Based on data collected by the authors, cows on many dairies experience a high risk for early lactation herd removal (typically, approximately 10-11% of all cows leave the herd within the first 60 days of calving through culling, death or to a much smaller degree, by sale to other herds for dairy purposes). This risk of removal is similar to the risk reported by Stewart and Godden from a large Minnesota record review.

The transition period is a critical time in cows' lactations with long lasting carry-over effects that extend far beyond a high risk of early lactation culling. There is a well documented depression in the immune function during this six week period. Dry matter intake may drop by 30% or more and the presence of various environmental, social, or feed related stressors may further compound the compromised DMI and immunity. Early lactation milk production, risk for contracting infectious diseases and subsequent antibiotic treatment, return to positive energy balance, and reproductive efficiency are all related to the success of the transition period.

Veterinarians, nutritionists and other dairy consultants are often asked to investigate, correct, or otherwise deal with the resulting problems caused by transition failures. For example, herds that struggle with poor reproductive efficiency may implement massive changes in the breeding program including the firing of commercial or on-farm inseminators. Nutritionists may be called regarding poor fresh cow milk production or poor peak performance. Often, these production and reproduction problems are the result of mismanagement that occurred at least 3-6 weeks previously. Examples of management issues that may lead to production problems include overcrowded close-up dry and fresh cow pens, inadequate heat stress abatement, and rations that somehow were not delivered as per the nutritionist's recommendations or were sorted by the cows. Unfortunately, key herd advisors at times may resort to finger pointing and playing the "blame game". However, each member of the herd management team has specific roles. Complete buy-in and cooperation from all members of the management team, as well as a concerted management effort targeted at prevention of periparturient problems is necessary to ensure the financial success of these large dairy enterprises.

The following checklist was designed to offer some guidelines to help veterinarians, consultants and owners/managers improve the management of transition cows with an eye on improved early lactation performance, decreased risk of premature culling, and improved reproductive success. It is not meant to be an exhaustive list of all possible transition issues, but merely to serve as an aid in the investigation of problems and in improving the day-to-day management. At the end of the paper is a list of reference/ suggested reading for those that would like additional information.

## Grouping & Pen Movement

- ❑ Goal: The goal is to reduce the social, environmental and metabolic stressors by minimizing the number of pen changes a cow is forced to make. Keep it simple - avoid unnecessary pen changes as each pen move is likely to result in a drop in feed intake and elevated cortisol levels, both of which may negatively impact immune function and overall health and productivity.
- ❑ When moves are necessary, decrease the impact of pen changes by moving animals once weekly and move in groups of 10 or more animals if possible.
- ❑ Avoid moving cows into new pens during the last 10 days prior to calving. Cows should spend at least 14 days in the close-up pen.
  - Due to the inevitable variation around calving dates, in order to have at least 90% of cows spend at least 10 days in close-up, the average days in close-up should be 23-24.
    - When moving cows from far dry to close-up on a weekly basis, set up the report to list cows that are 21 – 27 days prior to expected calving.
  - If possible, target slightly longer days in the close-up pen for cows known to be carrying twins or cows that are dry during summer heat stress conditions as they are expected to experience shorter gestation periods.
    - In these high risk animals, set the report specifications to move cows at 28 – 34 days prior to expected calving.
  - In the West, many herds house close-up cows in dirt lots with covered shade structures. In this situation, cows usually calve in the same lot, negating the need for a maternity pen unless dystocia is suspected.
  - One alternative that is gaining in popularity is the system of bedded packs for close-up and maternity cows. Cows do not move to a maternity pen, but instead calve in the same pen in which they are housed throughout the close-up period. The advantage is fewer pen changes and less need for an hourly walk-through. However, space per animal is important (~100 ft<sup>2</sup> per cow) as is attention to bedding maintenance.
  - If maternity pens are used, strive to move only at impending parturition, i.e., feet showing or other obvious signs of active labor. Moving cows during early parts of stage 1 labor may result in an increased risk of stillbirth. Animals should spend less than 12 hours in a calving pen.
    - In order to make this plan work, close-up pens must be closely monitored around the clock. A maternity worker should walk the pens approximately once every hour and move cows displaying signs of active labor. Facilities should be designed to allow a single worker to calmly move an animal from close-up to maternity without additional help and without undue stress of the animal or her pen mates.

- Waiting until active parturition to move cows from a freestall dry cow pen into a maternity pen usually will result in some cows calving in the freestalls. Cows vary in duration of active labor and some cows, especially older cows, spend very little time in active labor. Inevitably, even with very experienced workers, walking pens every hour will result in missed animals. As a consequence, expect about 10% of calvings to occur outside of the maternity pen (i.e., in the freestalls) and workers should be prepared to properly and promptly assist these calves.
- Separate heifers & older cows if possible.
  - Heifers have been shown to have longer resting times and higher DMI when separated from mature cows.
  - Some researchers feel that heifers need higher levels of protein during the close-up period (>15%) as compared to mature dry cows.
  - Feeding DCAD diets to springing heifers is not required since they are not susceptible to clinical hypocalcemia and are less affected by subclinical hypocalcemia than mature cows.
- Maintain the stocking density at less than 100%, based on feed bunk space.
  - Provide ~30" of bunk space per animal or, in pens with lock-ups spaced at 24", populate the pen at 80-85% of the number of lock-ups.
  - Producers often hear conflicting information regarding the pros and cons of using self-locking stanchions in transition cows.
    - Pros:
      - Lockups at the feedbunk provide more defined feeding areas and may reduce feed wastage from behaviors such as feed tossing.
      - Increasing evidence that there is a reduction in displacement of subordinate cows by dominant cows from the feed bunk when stanchions are in place as compared to post and rail feeding systems.
      - Lockups can dramatically improve labor efficiency, but make sure to remain aware of the cows' time budgets and the damage that may be done as a consequence of prolonged lock-up times.
    - Cons:
      - Cost is probably the biggest drawback.
      - A handful of cows may not comfortably use stanchions and may need to be sold to another dairy or moved to a pen that has open feeding areas.
  - Set realistic lockup expectations (large, wide-bodied dry cows will not use all of the slots when stanchions are 24 inches wide, i.e, 5-in-10 stanchions).
  - Instead of relying on a count of lockups, strive to always provide 30-36 inches of feed bunk access per cow in the close-up and fresh cow pens.
    - The easiest way to accomplish the desired stocking density is to count cows vs. bunk space on the day of move into the close-up pen. If there are 28-30 inches of useable bunk space per cow on the day of the move, as cows calve and move to other pens, the feed space per cow will only increase throughout the week.
    - Due to seasonal changes and normal variation in calving patterns, herds should plan to provide bunk space above and beyond the average number of

cows present at a given time in the close-up and fresh pens. For example, based on an evaluation of both southeastern and western herds, if the close-up pen was sized for 125% of the average pen size, the pens would exceed the desired 85% stocking density about a third of the time. If the pen was sized based on 150% of the average pen size, density would exceed 85% about 15% of the time, but would result in less than 24 inches of bunk space per cow less than 2-3% of the time, based on the herds evaluated.

- Maintain a clean, dry environment
  - Mud and heat stress increases metabolic needs but decreases feeding intake
  - Wet, mucky conditions also increase the risk of mastitis that may not appear until well in the fresh pen
  - Cows calving in wet conditions may experience higher risks of metritis
  - Maternity pens should be bedded with clean, dry material and changed frequently
    - Frequency of rebedding will depend on a variety of issues such as stocking density, bedding type, weather conditions, etc. Strive to maintain an area which results in cows maintaining good hygiene scores.
- Following calving, cows should be housed in a colostrum pen, instead of a hospital pen, if possible, until milk is free of dry cow antibiotic residues and legal for sale.
- Minimize distance walked in these tired and sore fresh cows by placing the pre- and post-fresh pens close to the parlor if possible.
- Design move lanes and coordinate cattle movement to eliminate lock out time away from feed

## **Nutrition & Feed Delivery**

- Goal: The primary feeding management goal during the prepartum period is to minimize the inevitable drop in dry matter intake that occurs prior to calving. Feed intake, energy balance, and the magnitude of change in both are associated with changes in immune function, risk of developing retained placenta and metritis, and with postpartum feed intake.
- Close-up cows:
  - Energy and protein requirements during the last week of gestation are estimated to be approximately 15 Mcals  $NE_L$  and 1100 grams of metabolizable protein per day, respectively.
    - It is beyond the scope of this paper to adequately describe the various strategies and guideline for balancing rations, but there are a few basics worth mentioning:
      - Ensure an adequate level of fiber intake by feeding 7 of 7.5 lbs of forage ADF and make sure cows are actually consuming the ration provided by using a Penn State Particle Separator to evaluate fresh vs. refusals
      - Increase metabolizable protein to approximately 1100 to 1200 g/d (corresponds to a positive balance of 400 to 450 grams of metabolizable in some ration balancing programs)
      - Be careful with fermentable carbohydrate levels – keep total NFC to less than 30 to 32% and starch at approximately 14-18%

- Monitor feed intake - this is one of the simplest monitors of change in performance (and predictors of future performance) but yet is most often overlooked.
  - Weigh feed delivered to close-up and fresh cow pens daily
  - Weigh feed refusals from close-up and fresh pens daily
  - Target a 5% refusal (or more) on a daily basis, but ensure that the ration is not easily sortable by grinding hays to less than 3 inches in length and adding water if necessary
  - Based on a typical 21-24 average days in close-up, shoot for a dry matter intake of greater than 26 lbs for mature Holsteins (> 18 lbs for mature Jerseys) and greater than 23 lbs for Holstein heifers (> 14 lbs for Jersey heifers) in close-up pen
- If using DCAD diets for close-up cows:
  - Select forages, grains and grain by-products with that are low in potassium to minimize the amount of anionic salts needed
  - Monitor urine pH's once weekly from ~ 10 cows while feeding a DCAD diet. The goal is to have all cows at 6.0 to 6.9 following at least 48 hours on the diet. Many people monitor the average pH but the average can be very misleading, especially in situations where cows are sorting the ration and some animals have a high pH while others are too low. Over-acidification (urine pH < 5.8) may result in depressed feed intake and perhaps compromised immune function while inadequate acidification (urine pH > 7.2) can lead to severe, non-responsive downer animals following calving. Either scenario can also result in an increase in retained placentas.
- Feed additional vitamin E to close-up and fresh cows. Vitamin E has been shown to improve immune function and decrease the risk of retained placenta, metritis and mastitis in fresh cows. Specific levels to feed depend upon type of diet and feed ingredients but many consultants recommend levels of 1800 to 3000 IU/ day in these high risk cows.
- Fresh cows:
  - Energy and protein requirements during early lactation change dramatically as milk production increases. After the prescribed withdrawal time, move cows from the colostrum pen to a fresh cow pen for ~ 10-21 days. Duration of time in fresh pen is dependent upon preferred feeding strategy, ability to feed a special fresh cow ration, and calving pressure. Once again, it is beyond the scope of this paper to adequately describe the various strategies and guideline for balancing rations, but there are a few basics depending on the management/ feeding option chosen:
    - Option 1 – short duration in fresh pen (10 to 14 days) with more aggressive protein feeding followed by move to normal high cow ration at 10 to 14 days in milk.
      - Ensure an adequate level of fiber intake by feeding approximately 7 lbs of forage ADF and total NDF levels at approximately 32%
      - Increase metabolizable protein balance to a positive 500 to 600 grams
      - Maintain correct blend of carbohydrates to drive propionate production but keep total NFC at 35-38%
    - Option 2 – move cows onto regular high cow ration

- Ensure an adequate level of fiber intake by feeding 7 to 7.5 lbs of forage ADF and total NDF levels at approximately 30 to 33%
    - Shoot for metabolizable protein balance of positive 250 to 400 grams through first 100 days in milk
    - Feed balanced carbohydrate blend of approximately 23-24% starch, 4.5 to 5% sugars, and 9.5 to 10% soluble fiber
  - In both scenarios, the goal is to ensure an adequate level of fiber intake to maintain rumen health while still providing the proper mix of fermentable substrate and nitrogenous sources (protein) to increase microbial numbers and propionate, the driver behind glucose/ lactose production and subsequently, milk production.
- Monitor feed intake
  - Weigh feed delivered and leftover daily as both a monitor and predictor of fresh cow performance.
  - Dry matter intake of >38 lbs for Holsteins (> 27 lbs for Jerseys) in mixed parity fresh pens (2-21 DIM)
    - Holsteins grouped by parity: 35 lbs for lact = 1 and 43 for lact > 1
- Continue feeding higher levels of vitamin E as described above if possible.
- Fat cows ( $\geq 4.0$  BCS) are at increased risk of ketosis and often benefit from oral drenching – consider 8–10 oz propylene glycol drench/ cow/ day or 1-1.5#’s calcium propionate/ cow/ day at calving and again in 24 hours, at calving and again in 24 hours
- General principles:
  - Ensure uniform feed intake by all animals
    - Monitor particle size using a particle separator
    - Maintain a moisture content of ration 48-55% to help reduce sorting & increase palatability (may need to add water to some rations)
    - Monitor manure for fiber length, grain particles & gas bubbles.
    - Pre-batch mix/ chop hays to control length to no larger than 2-3 inches (i.e., less than the width of a cow’s muzzle)
    - Use high quality, highly palatable hays free of mold & mycotoxins.
    - Use high quality, highly palatable silages free of clostridial or butyric acid fermentation problems. Do not feed silage from top & sides of silo to transition animals. Limit silages to no more than ~ 40 to 50% of forage needs in prefresh cows
    - Clean out feed bunks daily for both close-up and fresh cows to minimize risk of feed intake depression from moldy or heated feeds
  - Avoid overcrowding-Maintain the stocking density at less than 100%, based on feed bunk space. (provide ~30” of bunk space per animal or in pens with lock-ups spaced at 24”, populate the pen @80-85% of the number of lock-ups.)

## Facilities & Cow Comfort

- Goal: Maximize cow comfort to promote more lying time and to minimize additional metabolic needs associated with excessive standing and or walking.

- Fresh cows are at increased risk of lameness/ laminitis due to the influence of periparturient hormonal changes that may negatively impact foot and leg tissues and due to pen, ration and feed intake changes.
- Clean, dry & comfortable beds, lots or corrals.
  - Space requirements:
    - ~ 100 sq ft/ cow in bedded packs
    - ~ 500 to 600 sq ft/ cow of loafing area and 50-75 sq ft shade area/ cow in open corrals
    - A minimum of 1 properly bedded and maintained freestall / cow if using freestall housing is ideal
- Heat stress abatement is critical in both prefresh and fresh cows – Provide soaker lines on lockups during heat stress conditions that cycle once every 15 min. from 70-79°, once every 10 min. from 80-88° & once every 5 min. above 88°F with 0.33 gal.of water/cow/cycle.
- Minimize additional stressors by minimizing pen changes, maintaining low pen densities, separating heifers and cows, and by providing adequate water, bedding, nutrition, etc.
  - Provide a minimum of 3 linear inches of water trough access per cow divided into at least 2 locations with the pen
  - Separate cows from heifers during prefresh and postfresh periods to minimize antagonistic behavior toward heifers, promote better feed intake, and to promote improved resting times
  - Eliminate dead ends – temporary gates placed across freestall pens prevent cows from making an “escape” from larger boss cows and will often negatively impact both feed intake and resting opportunities
- Acclimate heifers to lockups/ stanchions and concrete feeding aprons if possible prior to entering the close-up pen.

### **General Items and Monitoring**

- All lactating cows are expected to lose some weight post-calving. Normal weight loss during first 30 DIM should be  $\leq 0.75$  BCS or ~90 lbs (1 BCS ~ 120 lbs of fat and protein)
  - First service conception risk may be reduced by 50% when BCS decreases by more than 1.0 score during the first 60 DIM
  - Risk of anovulatory condition (failure to cycle) increases in animals whose BCS falls below 2.75 or who lose excessive condition during the early postparturient period
- Use some form of a fresh cow monitoring and treatment program custom designed with your veterinarian to fit each farm’s needs.
  - No one program fits all herds, but most herds benefit from some sort of evaluation program to assess appetite, attitude, and appearance of every cow in the fresh pen every day. Depending on the amount of labor available, as well as the quality of the labor, some herds need a rigorous fresh cow monitoring program to prevent cows from “falling through the cracks”. If some form of a 10-day monitoring program is utilized, careful attention should be paid to ensure that fresh cows are not locked for more than 30-45 minutes per day.
  - Other herds that have very high quality herdsmen and fewer fresh cow issues may actually perform better with a prompted assessment approach instead of individually examining every fresh cow every day for the first 10 days of lactation.

- Record major, consistently defined fresh cow events such as milk fever, DA's, RP's, mastitis, metritis, lame, died, and sold in addition to freshenings.
  - Some events such as ketosis may be too subjective or prone to detection biases and are usually not as valuable to record. However, if recorded, monthly ketosis incidence can be used to evaluate employee performance.
  - Retained placenta risk, calculated on a weekly or monthly basis, can be a very good monitor of both preparturient feed intake as well as a predictor of future metritis risk.
  - Monthly risk of displaced abomasum (# of DA's divided by number of fresh cows at risk) can also be helpful to indicate transition problems but this metric suffers from more lag than RP risk.
  - In general, the following fresh cow event risks are achievable goals for most operations:
    - Milk fever – less than 3-5% of mature cow calvings
    - Displaced abomasum – less than 3-5% of all calvings
    - Retained placenta – less than 8% of all calvings
- Close-up urine pH and overall feed intake are two of the best predictors of future fresh cow problems.
- Many herd owners and consultants like to monitor fresh cow culling/ death risk. Following calving, less than 6% sold and 2% dead during first 60 DIM (expressed as total sold or died/ total calved) are achievable targets but this metric also suffers from lag to a greater degree and occurs too late to take action for affected cows. Also, some herds tend to play games to make this number look good by waiting until the next 30 day window to cull poor doing animals.
- When animals fail to peak—check total dry matter intake and ration protein levels – fresh cows need to rapidly increase feed intake and need adequate levels of high quality protein (more specifically amino acids) in order to achieve high peaks
  - In general, heifers should peak at ~ 75-80% of mature cow peaks.
  - Based on monthly test data, mature cows will typically peak at 50 – 75 DIM but heifers will peak later (90 – 120 DIM). In general, as milk production increases, DIM at peak increases slightly. Also, herds using rBST will also peak later, especially first lactation animals.
- When animals fail to persist—check body condition changes, dry matter intake and total ration energy levels – persistency is usually related to total energy intake
  - First lactation animals should have higher persistency than mature cows – 94-96% persistency (or 4-6% decline per month) as compared to mature cows with 90-93% persistency (or 7-10% decline per month)
- Heat stress conditions narrow the margin for error:
  - Total feed intake decreases, but maintenance requirements for energy are increased
  - Cow spend more time standing (higher risk for lameness)
  - Shorter gestation lengths
  - Higher risk for RP's and much higher risk for more severe metritis
- Fat cow problems should be addressed by strategic management of ketosis risk (propylene glycol or calcium propionate drenching), reducing weight swings in transition period, and improving breeding management to reduce long days open – not by the use of a “reducing diet” in late lactation or far-off dry period
- Minimize lockup times in stanchions – ideally, cows will be locked for no more than 30-45 minutes/ day for monitoring, breeding, vaccinations, urine pH's, etc

- Early lactation milk production (first test milk or week 4 milk production estimates) are better monitors of transition performance than waiting for peak milk
  - First test milk is the earliest production data that can be used to evaluate early lactation performance and impact of transition programs. The lag for this approach is 1-3 months shorter than relying on peak milk and allows for the inclusion of cows that may be culled prior to reaching true peak milk. However, this approach is subject to the impact of days in milk at the first test. To correct for this confounding, in large herds, first test milk can be limited to only evaluating animals that experience first test between 20-30 DIM (or some comparable range).
  - A useful approach that has gained in popularity is the use of week 4 milk. In DC305, an estimate of milk production during the fourth week can be calculated using item type 122 (weekly average milk on week “X” where “X” equals 4). This estimate will include data from more cows than only evaluating first test for cows that tested between 20-30 DIM and can be used to illustrate the impact of seasonal changes in early lactation performance as well as showing the impact of management changes.
- In herds with daily milk meters, changes in milk production can also be a good monitor but results should be interpreted with caution. In general,
  - Cows should increase in milk flow by ~ 10%/ day for first 14 days
  - Heifers should increase in milk flow by ~ 6 to 8%/ day for first 14 days
- Milk components can also be used at the herd level to indicate potential transition issues. Fresh cows that mobilize excessive body fat will often demonstrate higher than normal levels of butterfat. On an individual cow basis, the use of either first test fat percentage or fat:protein ratio is not very sensitive for identifying cows at increased risk of subclinical or clinical ketosis. However, at the herd level, examining the fat:protein ratio at first test can provide valuable information.
  - Calculate fat:protein ratio for cows with DIM at first test of 10-40. If 40% or more of this population has a fat:protein ratio  $\geq 1.4$ , further investigation is warranted.
  - Another approach is to look at first test fat percentage alone. In this case, if > 10% has an excessively high first test fat %, further investigation may be warranted. Cutpoints used by the authors for quick screening: 5.0 for Holsteins and 6.0 for Jerseys.

### **References and Suggested Readings**

Bell AW (1995), Regulation of organic nutrient metabolism during transition from late pregnancy to early lactation, *J Animal Sci* 73: 2804-2819

Bell, A. W., W. S. Burhans, and T. R. Overton. 2000. Protein nutrition in late pregnancy, maternal protein reserves and lactation performance in dairy cows. *Proceedings of the Nutrition Society* 59(1):119-126.

Butler WR, Smith RD (1989), Interrelationships between energy balance and postpartum reproductive function in dairy cattle, *J Dairy Sci* 72: 767-783

Comin A, Gerin D, Cappa A, Marchi V, Renaville R, Motta M, Fazzini U, Prandi A (2002), The effect of an acute energy deficit on the hormone profile of dominant follicles in dairy cows, *Therio* 58: 899-910

- Contreras LL, Ryan CM, Overton TR (2004), Effects of dry cow grouping strategy and prepartum body condition score on performance and health of transition dairy cows, *J Dairy Sci* 87: 517-523
- Drackley JK (1999), ADSA Foundation Scholar Award. Biology of dairy cows during the transition period: the final frontier?, *J Dairy Sci* 82: 2259-2273
- Drackley JK, Overton TR, Dowlen HH (2001), Adaptations of Glucose and Long-Chain Fatty Acid Metabolism in liver of Dairy Cows During the periparturient period, *J Dairy Sci* 84:
- Duffield, T. F., D. F. Kelton, K. E. Leslie, K. D. Lissemore, and J. H. Lumsden. 1997. Use of test day milk fat and milk protein to detect subclinical ketosis in dairy cattle in Ontario. *Canadian Veterinary Journal-Revue Veterinaire Canadienne* 38(11):713-718.
- Duffield T (2000), Subclinical Ketosis in Lactating Dairy Cattle, in *Veterinary Clinics of North America: Food Animal Practice*, p 231-253
- Grant R, Albright JL. Dry matter intake influenced by cow grouping, behavior. *Feedstuffs*, December 8, p. 12-16. 1997.
- Grummer RR (1993), Etiology of lipid-related metabolic disorders in periparturient dairy cows, *J Dairy Sci* 76: 3882-3896
- Grummer RR (1995), Impact of changes in organic nutrient metabolism on feeding the transition dairy cow, *J Animal Sci* 73: 2820-2833
- Hayirli A, Grummer RR, Nordheim EV, Crump PM (2002), Animal and dietary factors affecting feed intake during the prefresh transition period in Holsteins, *J Dairy Sci* 85: 3430-3443
- Ingvartsen KL, Andersen JB (2000), Integration of metabolism and intake regulation: a review focusing on periparturient animals, *J Dairy Sci* 83: 1573-1597
- Moreira F, Risco C, Pires MFA, Ambrose JD, Drost M, DeLorenzo M, Thatcher WW (2000), Effect of body condition on reproductive efficiency of lactating dairy cows receiving a timed insemination, *Therio* 53: 1305-1319
- Rabelo E, Rezende RL, Bertics SJ, Grummer RR (2003), Effects of transition diets varying in dietary energy density on lactation performance and ruminal parameters of dairy cows, *J Dairy Sci* 86: 916-925
- Reynolds CK, Aikman PC, Lupoli B, Humphries DJ, Beever DE (2003), Splanchnic metabolism of dairy cows during the transition from late gestation through early lactation, *J Dairy Sci* 86: 1201-1217
- Santos JE, DePeters EJ, Jardon PW, Huber JT (2001), Effect of prepartum dietary protein level on performance of primigravid and multiparous Holstein dairy cows, *J Dairy Sci* 84: 213-224

Santos JE, Juchem SO, Galvao KN, Cerri RL. (2003) Transition cow management to reduce metabolic diseases and improve reproductive management, *Proc Western Canadian Dairy Seminar*, March 11-14, University of Alberta, Edmonton, Canada.

Stokes SR, Goff JP (2001), Evaluation of calcium propionate and propylene glycol administered into the esophagus at calving, *Prof Anim Sci*. June: 115-122

Thatcher WW, Moreira F, Santos J, Staples CR. (2003) Factors influencing reproductive efficiency. *in proceedings* Fifth Western Dairy Conference, p. 107-115.

Vandehaar MJ, Yousif G, Sharma BK, Herdt TH, Emery RS, Allen MS, Liesman JS (1999), Effect of energy and protein density of prepartum diets on fat and protein metabolism of dairy cattle in the periparturient period, *J Dairy Sci* 82: 1282-1295



# Reproductive Efficiency and Economics of Timed AI vs. Natural Service

Carlos A. Risco<sup>1</sup>, Fabio Lima<sup>1</sup>, Marie-Joelle Thatcher<sup>1</sup>, Jose Santos<sup>2</sup>, Albert De Vries<sup>2</sup> and William W. Thatcher<sup>2</sup>

University of Florida

<sup>1</sup>College of Veterinary Medicine and

<sup>2</sup>Department of Animal Sciences

Gainesville, Fl. 32610

[RiscoC@vetmed.ufl.edu](mailto:RiscoC@vetmed.ufl.edu)

353-392-2212, ext 4109

## Introduction

Despite the advantages of artificial insemination (AI), natural service (NS) continues to be commonly used by dairy producers. A California survey revealed that 84% of dairyman use NS as a component of their breeding program management (Champagne et al., 2002). In dairy herds located in the northeast region of the US, reported use of NS, as a component of the breeding system, varied from 55 to 74% (NAHMS, 2002; Smith et al., 2004). In a study that compared pregnancy rates (PR) between AI and NS in Georgia and Florida dairy herds, the use of NS alone or in combination with AI was reported to be close to 70% (deVries et al., 2005). A survey that examined current management practices in 103 herds participating in the Alta Genetics (Watertown, Wi) Advantage Progeny Testing Program, reported that 43% of herds used a clean-up bull (Caraviello et al., 2006).

The main reason for using NS in dairy operations in the previously cited reports is the notion that more cows are bred by bulls compared to AI because human errors in heat detection are avoided when bulls are used. Systematic breeding programs for AI at a predetermined time (Timed AI; TAI), without the need for heat detection, coupled with early rebreeding of non-pregnant cows are successful options for reproductive management of lactating dairy cows. These systems optimize PR by synchronizing follicle development, regression of the CL, and precise induction of ovulation to provide a fixed TAI (Pursley et al., 1997; Thatcher et al., 2000, 2001 a, b, 2002). Incorporation of TAI in dairy herd reproductive management programs reduces labor requirements for heat detection while improving overall reproductive performance and maximizing profit (Risco et al., 1998 a, b). However, studies that compare reproductive performance between NS and TAI, two breeding systems where heat detection is not a factor are lacking.

This manuscript discusses methods that veterinarians and producers can use to improve management of NS breeding programs in dairy herds to optimize PR. Also, research that compared reproductive performance and economics between AI and NS breeding systems is presented.

## **Bull Selection**

Bulls for use in NS should be carefully selected for their primary task, which is to get cows pregnant. The ability of bulls to perform this task is dependent upon their semen quality, libido, mating ability and social ranking among bulls and cows. Therefore, as with beef bulls, it is recommended that NS bulls pass a breeding soundness evaluation, as recommended by the American Society for Theriogenology and repeated, at least, on an annual basis (Chenoweth P., 1992). In hot summer months, some reduction of bull fertility may be expected due to lowered semen quality associated with an increase in abnormal sperms. Breeding activity, a function shared by both males and females, is usually less during the hotter parts of the day in summer, although this is rectified during cooler periods. As females tend to exhibit lower estral behavior during hot weather, the inherent bull advantage in heat detection should compensate, at least in part, for lowered semen quality. Young bulls (2.5 years or less) are recommended because of the difficulties and dangers of handling older bulls on dairy farms. These young bulls should be fully pubertal (for Holsteins over 14 months of age) and of a size compatible with the cows that they need to service. However, younger bulls should not be used at low bull to cow ratios (BCR) as their reproductive capacity is not generally as high as that of older bulls.

Economic losses that occur from use of NS bulls due to the loss of potential genetic progress in milk yield are high. In the US, sire-of daughter pathway was shown to be the weakest area of genetic improvement because of extensive use of NS bulls with low genetic merit. To help reduce these losses from genetically inferior NS bulls, producers should consider using bulls for NS that are good enough for AI sampling. Dairy herds that exclusively use NS usually do not raise replacement heifers. Here, genetic improvement of the herd can be achieved by purchasing replacement heifers from breeders who are using AI with semen from proven bulls.

## **Bull Management**

With the understanding that bull fertility is an integration of biological and management factors, the potential for deviation in an expected level of fertility from bulls can occur if they are not properly managed. The problem is that research on management strategies to optimize fertility in dairy farms that use NS is lacking. Consequently, management recommendations have been made from research conducted on beef bulls and from experiences working with dairy clients who successfully manage NS (Overton et al., 2003; Risco et al., 1998).

Bulls should be subject to the same vaccinations as cows (except for brucellosis and trichomonosis), as well as the same treatments for parasites. Control of venereal diseases is essential to the success of NS. It is recommended that cows be vaccinated for vibriosis at least three weeks prior to breeding and receive a booster at 6 month intervals. Some success has also been reported with bull vaccination (Vasquez et al., 1983). Vaccination is also available for trichomonosis, but in breeding cows only. All bulls in production should be checked for trichomonosis at the time of the breeding soundness evaluation.

Obesity and lameness can negatively impact reproductive performance. Rations which are balanced for middle to high producing dairy cows contain higher energy, protein and calcium levels than those required by the bull. The excess in energy intake can predispose the bull to over conditioning and laminitis. Feeding bulls a high level of dietary calcium has been associated with lameness in

conjunction with bone lesions in the spine and hip regions. The dietary requirements for mature bulls regardless of genotype are similar to requirements of a dry dairy cow. Major determinants for lameness in bulls include feeding a lactating cow diet, which can contribute to laminitis, and confinement on hard unstable surfaces (e.g. concrete) for long periods of time. To avoid problems related to a lactating cow ration, evaluation of body condition and lameness should be conducted frequently in NS bulls. Factors which can reduce lameness in bulls include periodic rest, removal from concrete and feeding a dry-cow type ration.

In many dairy regions of the United States as much as 8 pounds (15% of ration dry matter) of whole cottonseed is fed in total mixed rations balanced for high producing dairy cattle. Thus, a mature Holstein bull with a dry matter intake of 13 kg could consume as much as 13 g of free gossypol per day. Whether or not gossypol intake at this level has a detrimental effect on bull fertility is not definitively known. An increase in sperm midpiece abnormality and a reduction in sperm production in Brahman bulls fed 2.75 kg of cottonseed meal (8.2 g of free gossypol per day) has been reported (Risco et al., 1993; Chenoweth et al., 2000). In contrast, Hereford bulls ingesting 7.6 to 19.8 g of free gossypol daily from whole cottonseed showed no significant sperm abnormalities (Cusak et al., 1995). The type of cottonseed product (meal vs. whole seed) fed may determine the extent of the toxicological effect as detoxification of gossypol in the rumen is more efficient with whole seed diets than with cottonseed meal diets.

The BCR is an important aspect of bull management. In contrast to beef herds, the optimal stocking ratio for dairy herds is not known, but probably differs depending upon housing environment and level of management. Overton et al. (2003), has suggested that for dry lot or pasture dairies, assuming that dairies will continue using young bulls, the proper BCR is most likely a 1 healthy and fertile bull per 20-25 non-pregnant cows, depending upon whether or not the cows have been synchronized before entering the pen. For free stall dairies, more bulls are likely required and a BCR of 1:15-20 non-pregnant cows is suggested.

Social effects may strongly influence bull reproductive success. With multi-sire groups, bulls lower in dominance rank may be inhibited by bulls of higher rank. In general, social rank is most influenced by age, or seniority, although body size, presence of horns and breed may also be important. The most serious effects of adverse bull interactions may be avoided by employing homogenous groups of younger bulls. However, as older females may also inhibit inexperienced young bulls, it is wise to monitor breeding activity, at least initially.

Safety is a major concern with bulls on dairy farms, partly because dairies often do not have adequate facilities, or personnel training, for bull handling. Bulls should be monitored for attitude and bad temperament should be a reason or excuse for culling. Due to a better temperament, younger bulls should be used and strict adherence to safety protocols must be followed. Accidents occur when people cut corners with safety protocols, particularly when they assume that a particular bull is safe. As bulls become more agitated (and dangerous) when separated, it is advisable to keep them within groups as much as possible.

An example of a bull management program developed by Dairy Production Systems of Florida (High Springs, Florida; <http://dpsdairy.com>) is shown in the sidebar and is printed with their permission.

### **All new bulls:**

All purchased bulls should be mouthed for age. Bulls greater than 18 mo of age should be rejected. All bulls must weigh 700-800 lb at the time of purchase and each bull should have its own unique identification number.

- Perform a Breeding Soundness Examination (**BSE**), test for trichomonosis and test for PI BVD by ear notch method.
- Vaccinations:  
IBR/BVD/PI3 & BRSV (Modified Live Vaccine) + 5-way Lepto and *L. borgpetersenii*.  
Repeat initial vaccination in 3 weeks.  
Clostridium 8-way  
Vibrio (Oil adjuvant): Revaccinate with Vibrio vaccine every 3 months.
- Parasite Control:
- Deworm and Delouse: Repeat 3 weeks after first application

### **Current breeding bulls (exposed to lactating cows)**

- All bulls must have a complete BSE every 6 months. After initial processing and clearance, bulls should be used for 6 months. After 6 months bulls should be re-tested and if satisfactory, they are used for another 6 months, after which the bull is culled.
- No bull is to be used in service for more than 12 months.
- Bulls are revaccinated at 6 mo. BSE check for Vibrio and the other vaccines are boosted in concert with the lactating herd.
- Bulls must be checked daily for lameness and any other health disorders. If a bull is lame, he should be removed from the cow herd and treated accordingly. He should be replaced immediately by a sound bull.
- Keep a minimum of 10 bulls in the resting pen ready to relieve any ill or lame bull. (These additional "bulls-in-reserve" represent about 10 % of the normal working population.)
- Monitor attitude daily. Any bull that becomes aggressive or difficult to handle must be culled ASAP.
- Check daily to make sure that bulls are in the correct pens and that bull-to-cow ratios are correct. Bulls should be rotated and rested after 14 d. Maintain 1 bull for every 20 open cows in each pen. After each palpation week, re-evaluate these ratios and adjust accordingly.
- Resting bulls receive the lactating cow TMR refusals (tends to be higher in fiber and contains less cottonseed and energy as the original feed, but yet decreases the risks associated with wholesale ration changes)

## **Reproductive management of cows**

In herds that use only NS the advantages of a fresh herd and a voluntary waiting period of 60 days should be considered. Fresh cows can be monitored daily for health and sick cows treated promptly without the nuisance of having a bull present. The fresh herd also allows a well balanced postpartum transition diet to be fed to reduce metabolic or digestive disorders. In a fresh herd, prostaglandin ( $\text{PGF}_{2\alpha}$ ) can be used to promote multiple cycles and uterine involution during postpartum in an attempt to increase pregnancy rate at first service. To help reduce the interval from calving to first

service cows may be treated with PGF<sub>2α</sub> prior to being exposed to the bull.

Breeding dates are not known in many NS herds and consequently days pregnant have to be estimated which results in too long or short dry periods. Palpation estimates of days pregnant are most accurate when cows are less than 65 days pregnant. The date when cows are first turned with the bull and the last examination date at which the cow was found open are important information for estimating days pregnant in cows bred by NS. Pregnancy diagnosis can be performed in cows 40 to 60 days after being turned with the bull. Cows that are open at pregnancy test can then be re-examined 30 days later. Cows that are found to be cystic can be treated with GnRH; use of PGF<sub>2α</sub> should be limited to cows with pyometra only. To monitor the presence of trichomonosis in a herd, it is beneficial to re-confirm pregnant cows around 120 days of gestation. Abortions due to T. foetus occurs during the first trimester of gestation and rarely after 5 months of gestation. Pyometra may be present in up to 10 percent of the cows in an outbreak of trichomonosis. Trichomonad pyometra is postcoital and not postpartum, but can occur after death of the developing embryo or early fetus. Cows with pyometra in NS herds should be cultured for T. foetus. Pregnancy in cows should also be reconfirmed prior to dry off similar to the practice used in A.I. herd around 180 to 200 days postpartum.

### **Economic Considerations of TAI and NS**

A study conducted in Florida, modeled potential net returns per cow by comparing use of TAI in winter and summer compared to insemination at detected estrus (Risco et al., 1998b). The greatest impacts on net returns were obtained when TAI was used during summer compared to winter. This finding was attributed to lower estrous detection rates observed during the summer months. It was concluded that use of a TAI program such as Ovsynch is an economical alternative in reproductive management of dairy herds with poor estrous detection. A TAI protocol using OvSynch was compared to AI at detected estrus in 2 large dairy herds differing in reproductive management (Tenhagen et al., 2004). Use of OvSynch reduced intervals to first AI and days open in both herds, as well as culling for infertility in herd 2. Conception rates for first AI at detected estrus were significantly higher compared to TAI in both herds and for overall inseminations at estrus in herd 2. For groups assigned to AI at estrus, mean 21-d submission rates over 200 d for AI were higher in herd 1 than in herd 2 (55.6 vs. 28.6 %). Days open and culling were the major cost factors. Although OvSynch improved reproduction in both herds, AI based on detected estrus was economically superior in herd 1, whereas OvSynch was superior in herd 2. The authors concluded that evaluation of synchrony protocols should consider reproductive performance along with costs associated with treatments. Such costs may offset benefits to reproduction in herds with good estrous detection rates.

A study conducted by Overton and Sisco (2005), used a partial budget approach to stochastically model the expected costs and return of reproductive management option in large western Holstein dairies. Two options were considered in the model. Option one, NS sires managed using recommended approaches such as BSE's, vaccinations and a rotational (rest) breeding system. Option two, included an AI system using a modified Presynch-OvSynch TAI program in conjunction with estrous detection and AI performed by professional itinerant breeders. The cost of the lactating ration, purchased cost of bulls, milk price, market value of bulls and net merit gains were considered as stochastic variables. The model showed that NS averaged approximately \$10 (USA) more in cost per cow per year compared to AI. However, there was a wide variation in expected differences in cost between the two breeding systems. Net merit estimates of bulls used for AI, prices received for

milk sold, and market price of bulls, in that order, had the greatest impact on costs between AI and NS breeding systems. Overton (2005) also calculated an extra cost of \$10.27 per slot per year for a NS program compared to an AI program including 30% TAI in large western Holstein dairy farms. He also assumed equal pregnancy rates. Overton assumed that for every two NS bulls, one extra cow could enter the herd. Thus, his AI program allowed for more cows than the NS program. When the number of cows in both programs was assumed equal, the extra cost per slot per year for a NS program was reduced to \$3.61.

A simulation study conducted in Greece evaluated data from 120 dairy farms to compare the costs associated with breeding dairy cattle by AI or NS (Valergakis et al., 2007). Calculations were based on direct AI and NS costs, and costs associated with an extended calving interval scenario for both breeding systems. Bull maintenance costs were from \$1000 to \$2100. Direct AI costs were higher for NS than AI for farms with more than 30 cows and extended calving interval resulted in major economic losses. Hypothetically, when use of NS resulted in a calving interval of 12 months, AI daughters with a calving interval of 13.5 months have to produce about 705 kg of additional milk to cover extra costs. Their actual milk production exceeded this limit by more than 25 %. When real calving intervals were considered (13.0 vs. 13.7 months for NS and AI, respectively) AI daughters produced more than twice the additional amount of milk needed. It was concluded that under less than average management conditions, AI is more profitable than the best NS scenario.

### **Studies Comparing NS vs. AI at Detected Estrus**

Several studies have compared reproductive performance between AI at detected estrus and NS breeding systems. Seasonal effect on AI and NS fertility in dairy herds was evaluated under field conditions using Dairy Comp 305<sup>®</sup> (Valley Agricultural Software, Tulare, CA) (Niles et al., 2002). During periods of heat stress (summer), overall PR dropped for cows bred by either AI or NS, and no difference in PR was found between NS vs. AI bred cows during the cool season. In herds with poor estrous detection, NS resulted in a higher PR (Niles et al., 2002). The effects of four combinations of AI and NS breeding systems (BS) on production and reproduction responses were evaluated using Dairy Herd Improvement Association herd summary information (Smith et al., 2004). Herds were assigned to BS by percentage of NS usage as follows: 1) 0%, 2) 1 to 20%, 3) 21 to 89%, and 4) 90 to 100%. Actual calving interval was shorter in herds that used mostly NS (BS4) compared with other systems. However, herds using a combination of AI and NS or mostly NS had longer dry periods than herds using all AI. Days dry and the percentage of dry periods greater than 60 d were less for herds that used all AI breeding. Overall efficiency assessed by the percentage of cows in milk and herd milk yield was greater for herds that used all AI and declined as the percentage of NS increased. The effects of AI and NS BS on PR by stage of lactation and season over an 8 year time period showed that the use of NS bulls did not result in meaningful advantages or disadvantages in terms of PR over time (deVries et al., 2005).

In contrast to the previously cited studies, a California study that compared calving to conception intervals for cows in AI pens with cows exposed to NS sires found that cows AI had a higher risk for pregnancy across all days in milk (Overton and Sisco, 2005).

### **NS vs. Timed Artificial Insemination**

A large study was conducted in Florida that compared reproductive performance between two

different breeding systems without heat detection; TAI and NS (Lima et al., unpubl.). One thousand fifty five lactating Holstein dairy cows from a single farm located in north central Florida were randomized at  $42 \pm 3$  d postpartum into two groups TAI (n=543) and NS (n = 512), and cows were blocked by parity (primiparous and multiparous).

Cows in the TAI group were pre-synchronized with 2 injections of PGF<sub>2α</sub> (25 mg; Estroplan<sup>®</sup>, Pfizer Animal Health, New York, NY) given at  $42 \pm 3$  and  $56 \pm 3$  d postpartum. Fourteen days after the second PGF<sub>2α</sub> cows were given an injection of GnRH (100 μg; Fertagyl<sup>®</sup>, Intervet Inc, Milboro, DE) followed 7 d later by an injection of PGF<sub>2α</sub>, and a second injection of GnRH 56 h after PGF<sub>2α</sub>. Timed AI was performed 16 h after the second injection of GnRH. Eighteen days after TAI, cows received a CIDR insert (Eazy-Breed; Pfizer Animal Health; New York, NY) followed by insert removal and GnRH administration 7 d later (25 d after TAI). Cows were diagnosed for pregnancy by ultrasonography examination at 32 d after TAI. The presence of an embryo with a heartbeat was the criterion for pregnancy. Cows diagnosed pregnant were re-examined by palpation per rectum of the uterus 28 d later (i.e., 60 d gestation) to reconfirm pregnancy status and to identify pregnancy loss. Cows diagnosed not pregnant at 32 d after TAI were administered PGF<sub>2α</sub>, followed with an injection of GnRH at 56 h after PGF<sub>2α</sub>. Timed AI was performed 16 h after GnRH. Cows not-pregnant were re-synchronized again with the same protocol until diagnosed pregnant or at a maximum of 223 d postpartum.

Cows in the NS group received PGF<sub>2α</sub> (25 mg; Estroplan<sup>®</sup>, Pfizer Animal Health, New York, NY) at  $d 42 \pm 3$  and  $56 \pm 3$  and moved to a bull pen at  $70 \pm 3$  d postpartum. The movement of cows into the bull pen 14 d after the last PGF<sub>2α</sub> treatment ( $70 \pm 3$  d postpartum) was performed to synchronize estrus and bull breeding close to 80 d postpartum, i.e. similar to the TAI group. After 42 d of being turned in with bulls, cows underwent an ultrasonography examination to determine pregnancy status. This allowed a diagnosable gestation length in pregnant cows to vary from 28 to 42 d. The presence of an embryo with a heartbeat was the criterion for pregnancy between 28 to 34 d by ultrasonography, and gestation length from 35 to 42 was determined by size of the amniotic vesicle. Cows diagnosed not pregnant were re-evaluated for pregnancy status 28 d later to allow pregnancy diagnosis in cows pregnant < 28 at previous diagnosis (i.e. now 28 to 56 d of pregnancy), utilizing the same criteria described above. This procedure was similar for subsequent groups assigned weekly to the NS group. Cows diagnosed pregnant were re-confirmed 28 d later to identify pregnancy loss. The BCR in the NS herds was one bull per twenty open cows. Bulls were used for one year and underwent a breeding soundness evaluation according to the American Society for Theriogenology prior to cow exposure and thereafter, every three months. Bulls classified as unsatisfactory (not sound) were removed and replaced with sound bulls. In addition, bulls were rested for 14 days after 14 days of cow exposure. All cows underwent a body condition score evaluation (BCS) at  $70 \pm 3$  d postpartum prior to being introduced with bulls (NS group) or receiving the GnRH injection (TAI group).

Outcomes of interest were days to pregnancy up to 223 days postpartum and PR per 21 day cycle (# pregnant/# eligible every 21 days). In cows bred by NS, days postpartum when pregnancy occurred was calculated by subtracting the days of pregnancy from the day postpartum when pregnancy was diagnosed. For example, a cow diagnosed pregnant 32 d at 130 d postpartum was pregnant at 98 d (i.e.130-32 d) postpartum. The interval between services in the timed AI group was 35 d due to the re-synchronization protocol employed. Therefore, for cows in the TAI group, day postpartum when pregnancy occurred to first, second, third or fourth service were classified as follows:  $d 80 \pm 3$  first

service;  $d 115 \pm 3$  second service;  $d 150 \pm 3$  third service; and  $185 \pm 3$  d for fourth service. For cows in the NS group, when pregnancy was diagnosed from 28 to 56 d, first, second, third or fourth services were classified at d 70 to 91, d 92 to 113, d 114 to 135 and 136 to 157 d postpartum, respectively. A cow in the NS group diagnosed 40 d pregnant at 150 d postpartum would have conceived at 110 d (i.e.  $150 - 40$  d) postpartum or at her second service.

Days to pregnancy was analyzed by survival analysis and conception risk using logistic regression. All models for reproductive outcomes included the main effects of treatment (NS vs. TAI), parity (primiparous vs. multiparous), BCS ( $\leq 2.75$  or  $> 2.75$ ), and season (Temperature Humidity Index [THI maximum  $\geq 72$ ]; Hot, April 22, 2007 to October 22, 2007; Cool, October 23, 2006 to April 21, 2007 and October 23, 2007 to March 13, 2008).

Table 1 shows the PR to the first two services in cows bred by NS or TAI. During the cool season, first service and second service PR for NS (36.98%, 29.85%, respectively) and for TAI (44.31%, 30.67%, respectively) did not differ. As expected, PR to first and second service was lower during the warm season, but did not differ between NS and TAI (27.36%, 24.04%; 27.06, 29.56%; respectively). This finding agrees with those of Niles et al., 2002, PR dropped during the warm season, but no difference was found for cows bred by AI or NS.

The proportion of pregnant cows by 223 d postpartum which was the end point of the study, was greater for NS than for TAI (NS=84.8% and TAI=76.4%,  $p=0.009$ ). The median time to pregnancy by 223 d postpartum was shorter for NS bred cows (111 days [95% CI = 104 to 125]) than TAI bred cows (116 days [95% CI = 115 to 117]) and is shown in Figure 1. The curves do not differ until 150 d postpartum, thereafter the two curves differ with a greater cumulative PR for the NS group. However, the rate when cows became pregnant during the first cycle at the end of the VWP between NS and TAI was different. For NS cows, PR to the first service cycle, 21 days after bull exposure (70 to 91 DIM), was 33.0% (cool and warm season) representing a PR of 1.57 cows / day. Conversely, for the TAI group, with a first service PR of 37% (cool and warm season) during the 10 days of the OvSynch and TAI protocol ( $70 \pm 3$  to  $80 \pm 3$  DIM), the PR was 3.7 cows per day. Figure 2 shows that 25 per cent of all pregnant cows conceived for NS at 84 DIM (95% CI=83to 86) and 81 days for TAI (95% CI = 80 to 82). We attribute this finding to the TAI management and not necessarily better fertility from TAI. In the NS group, pregnancy is dependent on the ability of the bull to identify cows in heat, breed, and impregnate them on a daily basis. When compared to NS, more cows are synchronized to be bred at a given service period in the TAI group. For the TAI group, it took five services for cows to become pregnant by 223 DIM. In contrast, cows in the NS group had more opportunities to be bred (at least 8 services) due to daily bull exposure and open cows re-cycling every 21. Reproductive outcomes are shown on table 2. Pregnancy rate per 21 days cycle were not different between TAI and NS (24.2% and 25.1%,; respectively,  $p = 0.93$ ).

Body condition score for first service and parity to overall PR affected pregnancy. Cows with a BCS  $\leq 2.75$ ; had lower odds to conceive (AOR= 0.73; 95 % CI= 0.56 to 0.99; (PR=32.33%) compared to cows with a BCS  $> 2.75$  which had a PR of 38.85%. Primiparous cows had greater odds to conceive (AOR = 1.91; 95 % CI = 1.32 to 2.88, PR= 87.32%) compared to primiparous cows (PR= 77.69%).

Critical to TAI programs is protocol compliance, semen handling and insemination technique. Pregnancy rates of 37 % to first TAI and 30 % to the re-synchronization (second service) of open cows indicate an acceptable response to TAI in the Florida study. We attribute the good reproductive

performance obtained in the NS group to stringent bull management practices employed; bull selection, periodic BSE's of all bulls, removal of bulls that were not sound, and replacing unsound bulls with sound bulls, allowing for a two week rest period, and a BCR of 1:20.

The costs and revenues of the NS program were compared to the TAI program in the Florida study. Partial budgets analysis was performed that considered explicit and implicit costs. Explicit costs were all accounting expenses that involve an actual cash payment. Implicit costs are an opportunity cost of foregone milk production that does not involve a cash payment. In the NS group, the following variables were used to evaluate explicit costs: price of purchase or production cost of bulls, management cost, housing cost, vaccination cost and feed cost of bulls, replacement cost of bulls culled prematurely, cost of BVD testing, cost of PGF<sub>2α</sub> to prevent uterine problems, health cost, cost of a breeding soundness evaluation and bull market return. In the TAI group, the following variables were used to evaluate explicit costs: cost of hormones used in the pre-synchronization, synchronization and re-synchronization protocols, cost of semen, cost of supplies to perform insemination and labor cost to perform AI. To evaluate implicit costs, the following variables were used: costs merit of genetic gain expected for NS and TAI based on the net merit for young sires and proven bulls used in TAI and net merit for NS sires for bulls used in NS breeding system. Labor costs and pregnancy rates in both programs were assumed equal. The net cost of the NS program was \$92.29 per cow slot per year. For the TAI program, the net cost was \$59.82 per cow slot per year. Therefore, the NS program cost \$32.47 per slot per year more. Net merit estimates of bulls used for AI and feed cost for NS bulls had the greatest impact on costs between AI and NS breeding systems.

### **Conclusion**

In herds with low PR related to poor heat detection, the use of TAI or NS are viable options. Both of these breeding systems require strict attention to management compliance in order to optimize reproductive performance. Natural service breeding programs are expensive when direct and indirect costs are considered. Utilization of TAI is less expensive than NS and allows for immediate submission rate of all animals at the designated waiting period.

### **References**

Caraviello, D. Z., K. A. Weigel, P. M. Fricke, M. C. Wiltbank, M. J. Florent, N. B. Cook, K. V. Nordlund, N. R. Zwald, and C. L. Rawson. 2006. Survey of management practices on reproductive performance of dairy cattle on large US commercial farms. *J. Dairy Sci.* 89:4723-4735.

Champagne, J. D., J. H. Kirk, and J. P. Reynolds. 2002. Bull management practices on California dairies: Implications for education and veterinary services. In *Proc. 15th Annual Fall Symp.* pp. 15-21.

Chenoweth, P.J., Chase, C.C., Risco, C, A, and R.E. Larsen. 2000. Characterization of Gossypol-Induced Sperm Abnormalities in Bulls. *Theriogenology* 53:1193-1203.

Chenoweth P. J. 1992. A New Bull Breeding Soundness Evaluation Form. In *Proc. Soc. Therio. Ann. Mtg.*, San Antonio, Texas.

Cusak, P. M. V. and V, Perry : 1995. The effect of feeding whole cottonseed on the fertility of bulls. *Aust. Vet. J.* 72:463-470.

deVries A., C. Steenholdt, and C. A. Risco. 2005. Pregnancy rates and milk production in natural service and artificially inseminated dairy herds in Florida and Georgia. *J. Dairy Sci.* 88:948-956.

National Animal Health Monitoring System. 2002. Part 1: Reference of dairy health and management in the United States. Ctr. Epidemiol. Anim. Health, Fort Collins, Co.

Niles, D., C. A. Risco, and M. J. Thatcher. 2002. Seasonal evaluation of artificial insemination and natural service pregnancy rates in dairy herds. *Comp. Cont. Educ.* pp. S44 to S48.

Overton, M. S., C. A. Risco, and J. C. Dalton .2003. Selection and management of natural service sires in dairy herds. *Proc. Ann. Conf. Amer. Assoc. of Bovine Pract.* Columbus, OH.

Overton, M.W. 2005. Cost comparison of natural service sires and artificial insemination for dairy cattle reproductive management. *Theriogenology* 64:589-602.

Overton, M.W., and W. M. Sisco. 2005. Comparison of reproductive performance by artificial insemination versus natural service sires in California dairies. *Theriogenology* 64:603-613.

Pursley, J. R., M. R. Kosorok, and M. C. Wiltbank. 1997. Reproductive management of lactating dairy cows using synchronization of ovulation. *J. Dairy Sci.*80:301-306.

Risco, C. A, P. J. Chenoweth, R. E. Larsen, J. Velez, N. Shaw, T. Tran, and C. C. Chase, Jr. 1993. The effect of gossypol in cottonseed meal on performance, hematological and semen traits in post pubertal Brahman bulls. *Theriogenology* 40:629-634.

Risco, C. A., F. Moreira, M. DeLorenzo, L. F. Archbald and W. W. Thatcher. 1998a. Timed artificial insemination in dairy cattle – Part I. *Comp. Cont. Educ. Pract. Vet.* 20(10):280-287.

Risco, C. A., F. Moreira, M. DeLorenzo, L. F. Archbald, and W. W. Thatcher. 1998b. Timed artificial insemination in dairy cattle – Part II. *Comp. Cont. Educ. Pract. Vet.* 20(11):1284-1290.

Smith, J. W., L. O. Ely, and W. D. Gilson, and W. M. Graves. 2004. Effects of artificial insemination vs natural service breeding on production and reproduction parameters in dairy herds. *Prof. Anim. Sct.* 20:185-190.

Thatcher, W. W., D. J. Patterson, F. Moreira, M. Pancarci, and E. R. Jordan. 2001a. Current concepts for estrus synchronization and timed insemination. *34th Ann. Proc. Am. Soc. Bovine Pract.* 34:96-105.

Thatcher, W. W., F. Moreira, J. E. P. Santos, R. C. Mattos, F. L. Lopes, S. M. Pancarci, and C. A. Risco. 2001b. Effects of hormonal treatments on reproductive performance and embryo production. *Theriogenology* 55:75-89.

Thatcher, W. W., F. Moreira, S. M. Pancarsi, J. A. Bartolome, and J. E.P. Santos. 2002. Strategies to

optimize reproductive efficiency by regulation of ovarian function. *Domest. Anim. Endocrinol.* 23:243-254.

Thatcher, W. W., R. Mattos, F. Moreira, M. Binelli, and J. D. Ambrose. 2000. Experimental manipulation of follicular growth. *Reprod. Domest. Anim. (Suppl 6)*:27-33.

Thatcher, W.W., F. T. Silvestre, C. A. Risco, J. E.P. Santos and C.R. Staples. 2006. Improving pregnancy maintenance in dairy cows. *J. Reprod. Dev.* 52:121-130, Suppl.

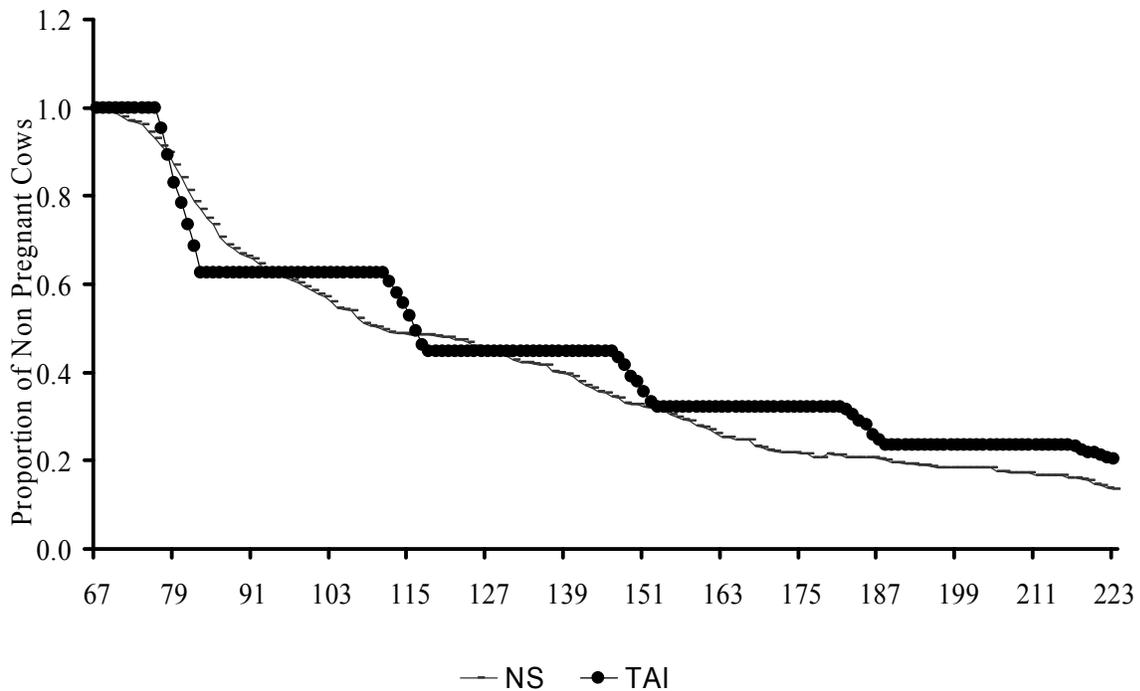
Valergakis, G. E., G. Arsenos, and G. Banos. 2007. Comparison of artificial insemination and natural service cost effectiveness in dairy cattle. *Anim. Cons.* 1:293-300.

Vasquez, L.A., L. Ball, B. W. Bennett, G. P. Rupp, R. Ellis, J. D. Olson, and M.H. Huffman. 1983. Bovine genital campylobacteriosis (vibriosis): vaccination of experimentally infected bulls. *Am. J. Vet. Res.* 44:1553-1557.

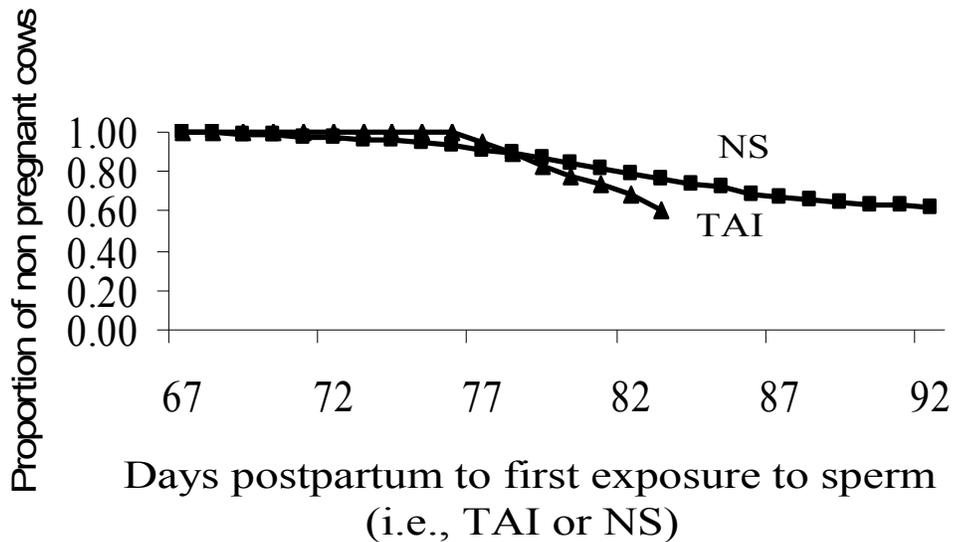
**Table 1.** Pregnancy rate for first and second service in lactating dairy cows bred by NS or TAI. Season affected pregnancy but there was no season by treatment effect.

	First service		Second service	
	NS	TAI	NS	TAI
Cool Season	36.98% (115)	44.31% (144)	29.85% (60)	30.67% (50)
Warm Season	27.36% (55)	27.06% (59)	24.03% (31)	29.56% (47)

**Figure 1.** Survival curves for proportion of non pregnant cows by days postpartum. The median time to pregnancy by 223 d postpartum was shorter for NS bred cows (111 days [95% CI = 104 to 125]) than TAI bred cows (116 days [95% CI = 115 to 117])



**Figure 2.** Survival curves for proportion of non pregnant cows based on an US pregnancy diagnosis at d 32 for cows bred by TAI (▲) and d 28-56 for cows bred by NS (■) to first service. Twenty five per cent of all pregnant cows conceived for NS at 84 DIM (95% CI=83 to 86) and 81 days for TAI (95% CI = 80 to 82)



**Table 2.** Reproductive responses for cows bred by TAI or NS

Variables	TAI	NS
Cows inseminated or exposed to the bulls by 223 DIM	543	512
Proportion of cows pregnant in the 1st 21 d breeding	37.4 %	34.4 %
Cows pregnant by 223 DIM	415 (76.4 %) <sup>b</sup>	434 (84.8 %) <sup>a</sup>
Mean days open in pregnant cows ( $\pm$ SEM)	113.2 $\pm$ 2.0	115.9 $\pm$ 1.9
Median days open	116 <sup>a</sup>	111 <sup>b</sup>
Cow-days at risk <sup>1</sup>	29,424	30,978
Pregnancies/1,000 cow-days at risk	14.10	14.00
21-d cycle pregnancy rate, %	24.2	25.1

<sup>a,b</sup> Superscripts

in the same row differ ( $P < 0.05$ )

<sup>1</sup> Cumulative number of days for cows between exposure to bulls and pregnancy or end of study in NS, and between first service and pregnancy or end of study in TAI.



# Heat Detection Accuracy and AI Technician Evaluation

Joseph C. Dalton, Ph.D.  
Associate Professor, Extension Dairy Specialist  
University of Idaho, Caldwell Research and Extension Center  
jdalton@uidaho.edu

Amin Ahmadzadeh, Ph.D.  
Associate Professor of Dairy Science  
University of Idaho, Moscow  
amin@uidaho.edu

## Take Home Messages

The following points are important to remember in the quest to achieve a successful dairy reproductive program:

- Pregnancy rate is a sensitive and valuable indicator of reproductive performance.
- Insemination risk and conception risk are components of pregnancy rate.
- Low heat detection accuracy can reduce conception risk and ultimately decrease pregnancy rate.
- In an on-going heat detection accuracy study, the percentage of cows not in heat when inseminated varied between herds, from 0 to 13%, signifying a specific individual herd problem. Overall the average heat detection accuracy across all 10 dairies was 95.3%.
- Evaluate AI technicians by
  - considering the numbers necessary to draw meaningful conclusions,
  - going behind the numbers and stratifying by insemination code or lactation number,
  - asking the question: Are the AI technicians breeding the same types of cows?
  - comparing like groups, or “apples to apples” and not “apples to oranges.”
- Proper semen handling and deposition of semen is critical to the success of an AI program.
- Continuing education is important to the success of an AI technician’s career and to the profitability of a dairy.

## Introduction

Reproductive performance has declined over the last few decades in U.S. dairy herds (Lucy, 2001; Washburn et al., 2002; de Vries and Risco, 2005). The downward trend in reproductive performance is disturbing and has eroded the profitability of dairies. The loss of potential income for each day a cow remains non-pregnant over 100 days in milk has been estimated at \$0.42 to \$4.95 per day, depending on stage of lactation (French and Nebel, 2003). In 2008, the average days open for southwestern, northwestern and eastern dairy herds that processed records at DHI-Provo was 149, 154, and 165 days, respectively (DHI-Provo, 2008).

Pregnancy rate is defined as the percentage of eligible cows that become pregnant within a given time frame. **Pregnancy rate (PR) is a timely measurement, and as such, is a more sensitive and valuable indicator of reproductive performance than average days open.** Nationally, average 21-day pregnancy rates have been reported to range between 12 to 16% (Buelow et al., 1999; Niles et al., 2001). According to Overton (2008) the optimal 21-day pregnancy rate approaches 30%.

What's the value of an increase (or decrease) in pregnancy rate? Depending upon milk price and milk yield, each 1% increase (or decrease) in pregnancy rate results in the gain (or loss) of approximately \$12 to \$25 per cow per year (Overton, 2001, 2005, 2008). Why? Because as pregnancy rate increases, over time the average days in milk for the milking herd will decrease, leading to higher average milk production per day of lactation, more time per lifetime spent in the most profitable portion of lactation, and less veterinary and breeding costs. As pregnancy rate decreases, average days in milk increases, leading to increased management, feed, and veterinary costs for cows in the least profitable portion of lactation.

Insemination risk (**IR**) and conception risk (**CR**) are components of PR. Insemination risk (formerly known as heat detection rate) is the percentage of eligible cows that are inseminated within a given time frame (including animals inseminated following a detected heat or a timed AI), while conception risk (formerly known as conception rate) is the total number of pregnant cows divided by the total number of inseminated cows with known outcomes (Overton et al., 2007). Thus, an increase (or decrease) in PR may be traced to an increase (or decrease) in IR, CR, or both components. In order to troubleshoot low PR in a herd, factors that impact IR and CR must be identified, and a plan must be made to alleviate problems associated with the factors identified.

### **Factors affecting conception risk**

Heat detection accuracy is defined as the proportion of detected periods of heat in which cows were truly in heat, as evidenced by low progesterone concentration in milk or blood. **Simply stated, if a cow is inseminated when not in heat, there's little to no chance of a pregnancy resulting from that particular insemination. Consequently, low heat detection accuracy can reduce CR and ultimately decrease PR.**

Other than heat detection accuracy, what else impacts CR and ultimately PR? Other factors may include fertility and general health of the cow, timing of insemination relative to heat or ovulation, semen handling, AI technique, semen quality, increased environmental temperature, and compliance with estrous or ovulation synchronization protocols. Although heat detection accuracy, semen handling, and AI technique are all under the control of the AI technician, evaluation of AI technicians based on conception risk should be done with caution. Prior to the discussion on AI technician evaluation, however, we'll discuss 1) previous heat detection accuracy research, and 2) current data from an on-going heat detection accuracy study. Finally, at the end of this paper we'll briefly review semen handling and site of semen deposition.

## Previous heat detection accuracy research

The failure to accurately detect heat is a common and costly problem of AI programs and a major limiting factor of reproductive performance on many dairies (Nebel and Jobst, 1998). Published literature provides evidence that heat detection accuracy varies widely. As previously mentioned, heat detection accuracy is defined as the proportion of detected periods of heat in which cows were truly in heat, as evidenced by low progesterone concentration in milk or blood. Progesterone concentration in blood and milk is associated with events of the estrous cycle as concentration is low (~1.0 ng/mL or less) for 2 d prior to heat and remains low for approximately 2 to 3 d after heat (Figure 1; Senger, 1999; Hopkins, 1989; Nebel et al., 1987). Low milk or blood progesterone *alone* is not an indicator of heat; however, high milk or blood progesterone is considered a *confirmation that a cow is not in heat*.

Using milk progesterone analyses, Reimers et al. (1985) reported the proportion of cows not in or near heat when inseminated varied from 0 to 60% among dairy herds, signifying a specific individual herd problem. Nebel et al. (1987) also reported highly variable heat detection accuracy among AI personnel and argued that errors in heat detection should be considered “a significant cause of low conception rates.” Nevertheless, one limitation of previous studies is the use of small herds (~42 to 300 cows; Reimers et al., 1985; Nebel et al., 1987) and the inclusion of up to 10 producer-identified signs of heat, ranging from “standing” (presumably as determined by visual observation) to “blood on the vulva.”

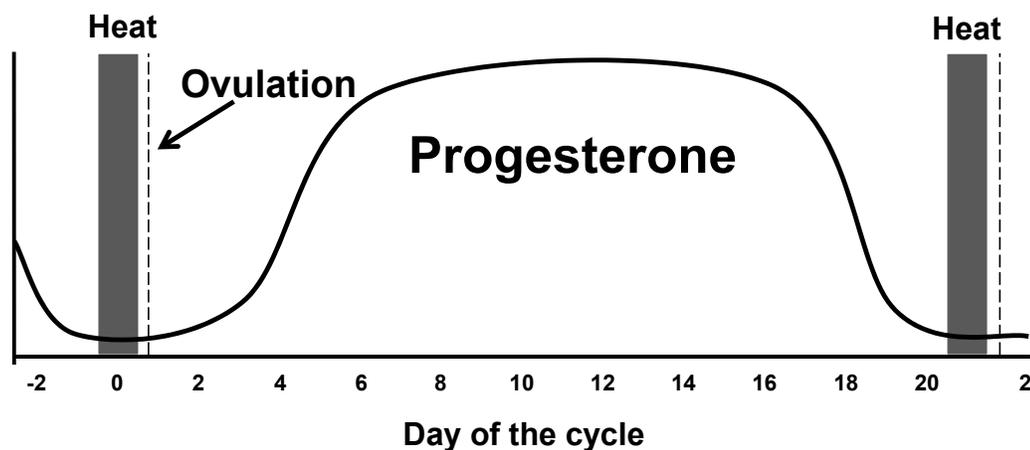


Figure 1. Progesterone concentration in blood during the estrous cycle of the cow (Courtesy of H. Lopez, 2008).

Visual observation (defined as specifically watching a group of cows for a period of time without performing another duty) almost never occurs on large dairies. Consequently, labor efficient management strategies such as once-daily heat detection, via daily tail chalk or paint application and subsequent identification of ruffled hair on the tailhead or lost chalk or paint, and once-daily AI are

more common. Therefore, current management strategies on large dairies require that cows are restrained in headlocks daily, during which time tail chalk or paint is applied and read in a matter of seconds as AI personnel walk behind the cows.

Another limitation of previous work includes the use of professional AI technicians who inseminated cows detected in heat by the dairy herd owner or farm personnel (Reimers et al., 1985). Heat detection by the herd owner coupled with AI by a professional AI technician is a practice still in use on some small dairies, in certain geographic regions of the U.S. In contrast, professional AI technicians or herdsman-inseminators perform *both* heat detection and AI on large dairies.

Lastly, in a case study conducted in a 3,000 cow California dairy (Moore et al., 2005), 91.8% (350/381) of cows sampled had low blood progesterone concentration on the day of insemination. Unfortunately, the data does not truly describe heat detection accuracy, as greater than 50% of cows were inseminated “at the completion of a timed AI program,” and by definition, were not detected in heat and then inseminated. Therefore, the question remains, what is the heat detection accuracy of AI technicians on large, modern dairies?

### **Current heat detection accuracy study**

A study is underway to determine the heat detection accuracy, as measured by plasma progesterone concentration, of AI technicians working with lactating dairy cows housed in open lots or free-stalls in large dairies. This research focuses on dairies that use once-daily tail chalk for heat detection. Data from herds using professional AI technicians or herdsman-inseminators to detect heat and perform AI are (and in the future, will be) included.

On the day of AI (or the day after AI), one blood sample was obtained from a minimum of thirty lactating cows detected in natural heat or a prostaglandin-induced heat. No blood samples have been obtained from cows receiving timed AI. Samples were analyzed for progesterone concentration. High blood progesterone (> 1 ng/mL) is considered a confirmation that cows were not in heat when they received AI.

Figure 2 depicts the results from 10 Idaho dairies ranging in size from 1,200 to 5,200 lactating cows. Similar to the results of Reimers et al. (1985) and Nebel et al. (1987), the percentage of cows not in heat when inseminated varied between herds, from 0 to 13%, signifying a specific individual herd problem. Overall the average heat detection accuracy across all 10 dairies was 95.3%.

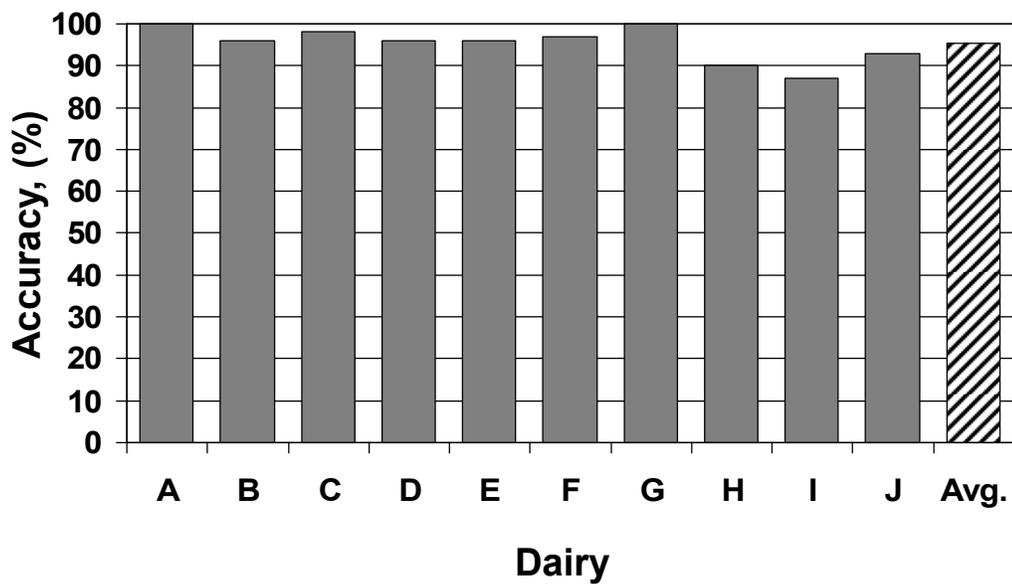


Figure 2. Heat detection accuracy results for 10 Idaho dairies.

The average insemination risk for the 10 herds was 62% (range 49 – 70%). The average conception risk was 29% (range 18 – 36%). Finally, the average 21-day pregnancy rate (for the period that included the blood sampling date) was 18% (range 10 – 24%).

So, have we answered the question regarding the heat detection accuracy of AI technicians on large, modern dairies? Preliminary data provides evidence that AI technicians can use tail chalk and detect heat with high accuracy, although specific individual herd problems appear to exist. Consequently, to adequately characterize heat detection accuracy on large dairies, data collection will continue until at least 20 dairies comprise the data set.

### AI technician evaluation

In the preceding section of this paper we've seen evidence that there are AI technicians that can detect heat with high accuracy. Further technician evaluation can provide valuable insight into the success or inadequacies of a reproductive program. Nevertheless, how do we evaluate technicians fairly? Start by considering the number of inseminations necessary to draw meaningful conclusions. Realistically, a *minimum* of 250 observations per insemination code or technician is recommended. When possible, go behind the numbers and stratify by insemination code or lactation number. Ask the question: Are the AI technicians breeding the same types of cows? Are all technicians breeding throughout the year or only during a specific season? Compare like groups, or “apples to apples” and not “apples to oranges” and try to determine if perceived differences in CR are real. Lastly, keep in mind that CR is a component of PR, and that PR is really the important monitor of success.

The purpose of this section is to provide a starting point for the evaluation of AI technicians. The suggestions provided here are not intended to be used as a step-by-step method, but rather to show a logical progression into the evaluation of AI technicians based on CR. The reader is cautioned that there are many ways to evaluate records; however, the evaluator should always search for meaningful data from which reasonable decisions may be made. Lastly, the authors do not support one product over another and any mention of a particular product is meant solely as an example, and not as an endorsement.

### Scenario 1- The basics

If a technician named “Junior” has a CR of 37%, and a technician named “Bob” has a CR of 32%, are these two numbers different? (Table 1; circle). At first glance, it appears that there is a 5 percentage point difference in conception risk. However, is the apparent 5 percentage point difference **real**?

To answer this question, we must first briefly discuss the confidence interval (CI). A confidence interval is a range around a mean (or average) that has a certain probability of containing the true mean (or average). Relative to the term “95% confidence interval (or 95% CI),” it is important to remember that in repeated sampling of data, we are 95% confident that the mean (or average) will reside within the intervals calculated.

Table 1. Dairy Comp 305 report (bredsum\x) showing the 95% CI, percent CR, and count (number) of inseminations.

95% CI	Total
Bob	29-35
Junior	32-43
Percent	
Bob	32
Junior	37
Count	
Bob	882
Junior	270

Note that the 95% CI for Bob is 29-35, while it is 32-43 for Junior (Table 1; square). **Do the confidence intervals for Bob and Junior overlap? Yes, they do. Therefore, the mean percentage CR (Bob 32% vs. Junior 37%) is NOT statistically different.** What does this mean? It means that there is not enough evidence to say that Bob and Junior actually have a different CR. One facet you should have noticed is the difference in the width (range) of the confidence intervals for the two

technicians. As observations (number of inseminations) go up (Table 1; Bob = 882; triangle), the width of the confidence interval narrows (29-35, or a 6 percentage point range). Conversely, when there are fewer observations (Table 1; Junior = 270; triangle) the width of the confidence interval increases (32-43, for an 11 percentage point range).

### Scenario 2-What’s behind the numbers?

Mark and Neil are AI technicians at a 9,000 cow dairy. Mark has an overall CR of 31%, while Neil has an overall CR of 26% (Table 2; circle). The data shown in Table 2 is from Dairy Comp 305 (bredsum\t).

Table 2. Conception risk (CR) for two AI technicians.

Technician	% CR	# Preg	# Open	Total
Mark	31	926	2,060	2,986
Neil	26	407	1,158	1,565

To begin the process of trying to determine if in fact the CR of these two AI technicians is really different, examine the breeding codes (bredsum\o) (Table 3). Although all inseminators are included in this report, this will give you a feel for the distribution of inseminations, that is, what percentage occur after 1) heat is detected, 2) Ovsynch, 3) Resynch, or 4) other programs.

Table 3. Conception risk (CR) by breeding code.

Code	% CR	# Preg	# Open	Total	% Total
Ovsynch1	28	461	1,188	1,649	6
Ovsynch2	27	297	788	1,085	4
Heat	32	6,194	13,083	19,277	66
Resynch	22	1,526	5,488	7,014	24

A quick glance at the data in Table 3 shows that 66% of all inseminations occur after heat detection (rectangle) . In contrast, only 24% of inseminations are the result of Resynch. Next, compare and contrast the results of Mark and Neil, by breeding code, for first lactation cows only (bredsum\x, click “options,” then click “lact 1.”) The data is shown in Table 4.

If we look at the “Count” (number of inseminations; see circle) for Mark and Neil in Table 4, it quickly becomes clear that we are NOT comparing “apples to apples.” For first lactation animals, Mark has 1,584 inseminations whereas Neil has only has 80 inseminations. Also notice the wide CI (15-33) for Neil and how it overlaps with Mark’s CI. Consequently, ferreting out potential

differences between these AI technicians in first lactation cows would be meaningless. So where may the potential differences be? Let's look at second and greater lactation cows, while excluding first lactation cows (bredsum\x, click "options," then click "lact = 2" and "lact 2+"). The data is shown in Table 5.

Table 4. Confidence intervals (CI), conception risk (CR), and count (number) of inseminations by breeding code<sup>1</sup>.

95% CI	Total	Resynch	Heat	Ovsynch1	Ovsynch2
Mark	28-33	17-26	30-35		22-43
Neil	15-33		18-38		
Percent					
Mark	30	21	33		32
Neil	23		26		
Count					
Mark	1,584	321	1,146	44	73
Neil	80	8	72		

<sup>1</sup>First lactation animals only.

Table 5. Confidence intervals (CI), conception risk (CR), and (count) number of inseminations by breeding code<sup>1</sup>.

95% CI	Total	Resynch	Heat	Ovsynch1	Ovsynch2
Mark	29-34	20-29	31-38	27-49	19-39
Neil	24-28	17-23	31-39	18-29	14-29
Percent					
Mark	32	24	34	38	28
Neil	26	20	35	23	21
Count					
Mark	1,402	336	916	72	78
Neil	1,485	621	521	231	112

<sup>1</sup>Second and greater lactation animals.

At first glance at Table 5 (see the vertical box) the CR difference between Mark and Neil appears to be real because the confidence intervals (Total column) do not overlap. **However, it is important to note that the individual 95% confidence intervals for each breeding code do in fact overlap (see horizontal box).** Furthermore, although we can see that Mark and Neil each have greater than 1400 inseminations of second and greater lactation cows, we have not yet fully answered the question: **Are the technicians breeding the same type of cows?** Continued analysis of the data in

this table is warranted to attempt to understand whether the distribution of inseminations among breeding codes is different for Mark as compared with Neil.

The data in Table 6 was taken directly from Table 5. Over 65% of inseminations performed by Mark are in cows identified in heat (Table 6; box) which, as shown previously (Table 3) has the highest CR of all breeding codes (across all technicians; 32%). Neil, however, has nearly twice as many inseminations following Resynch (Table 6; box) as compared to Mark, which, as shown previously (Table 3) has a CR (across all technicians; 22%) much lower than that following heat (32%). Neil is also at a further disadvantage because he has performed only half as many inseminations to cows identified as in heat.

Table 6. Distribution of inseminations, by breeding code, for each technician<sup>1</sup>.

Technician	Type of insemination, %, (n/total)			
	Resynch	Heat	Ovsynch1	Ovsynch2
Mark	24 (336/1402)	65 (916/1402)	5 (72/1402)	6 (78/1402)
Neil	42 (621/1485)	35 (521/1485)	15 (231/1485)	8 (112/1485)

<sup>1</sup>Second and greater lactation animals.

At this point, there is not enough data to support the belief that there is a difference in the success, (as measured by CR), of Mark and Neil. Instead, there is ample evidence that Mark and Neil are not breeding the same types of cows, and that the perceived difference in CR is most likely a result of the proportions of types of cows being inseminated by each technician. It is very important that managers and dairy producers employ a logical approach and exercise caution when evaluating AI technicians. A rash decision, based on insufficient data, could cost the technician his job, and the dairy a technician who, in reality, was doing a reasonable job.

Additional caution is warranted when evaluating a new technician. As described by Overton (2007), CR is determined using inseminations with known outcomes. Consequently, a new technician's early CR will tend to be biased downward because negative outcomes (conception failure) will be gained earlier when cows return to heat, as opposed to positive outcomes (pregnancies), which will lag due to the difference in time for outcome determination (Overton, 2007).

### Technician management: Semen handling and site of semen deposition

When numerous cows must be inseminated on a given day, AI technicians routinely thaw multiple straws of semen simultaneously to facilitate AI in a timely manner. In 2004, Dalton and coworkers conducted a field trial to answer the following questions:

- What is the effect of simultaneous thawing of multiple straws of semen and sequence of insemination (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> or 4<sup>th</sup>) on CR?
- Are conception risks achieved following AI by professional AI technicians (**PAI**) and herdsman-inseminators (**HI**) different?

- What is the effect of elapsed time from initiation of thawing straws of semen to seminal deposition on CR?

Although the average CR differed between PAI and HI (45% vs. 27%, respectively), simultaneous thawing and sequence of insemination (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> or 4<sup>th</sup>), and elapsed time from initial thaw to completion of fourth AI had no effect on CR within inseminator group (Dalton et al., 2004).

Nevertheless, a general recommendation as to the number of straws that may be thawed simultaneously detracts from the overall importance of proper semen handling for successful AI.

Conception risk is most likely to be maximized when personnel:

- accurately identify and administer the appropriate treatments to all cows to synchronize heat or ovulation,
- accurately identify cows in heat,
- follow the AI stud's recommendations for thawing semen,
- prevent direct straw-to-straw contact during thawing to avoid decreased post-thaw sperm viability as a result of straws freezing together,
- use appropriate hygienic procedures,
- maintain thermal protection of straws during AI gun assembly and transport to the cow,
- deposit semen in the uterus of the cow within approximately 10-15 minutes after thawing.

Many studies have compared semen deposition near the greater curvature of the uterine horns with conventional deposition into the uterine body. Although Senger et al. (1988), López-Gatius (1996), and Pursley (2004) reported increased fertility when semen was deposited in the uterine horns rather than the uterine body, Hawk and Tanabe (1986), Williams et al. (1988), and McKenna et al. (1990) found no difference in fertility when comparing uterine body and uterine horn inseminations. Furthermore, Diskin et al. (2004) reported an inseminator and site of semen deposition effect (interaction), with evidence of either an increase, decrease, or no effect of uterine horn deposition on conception risk for individual inseminators.

Unfortunately, it is not clear why a few studies have shown a fertility advantage following uterine horn insemination while others have not. A possible explanation for the positive effect of uterine horn inseminations may be related to the minimization or elimination of cervical semen deposition. Cervical insemination errors account for approximately 20% of attempted uterine body depositions (Peters et al., 1984). Macpherson (1968) reported that cervical insemination resulted in a 10% decrease in fertility when compared with deposition of semen in the uterine body. To maximize conception risk, all AI technicians must develop sufficient skill to recognize where the tip of the AI gun is at all times.

Attention to detail is an important trait of successful AI technicians, whether it is in the areas of heat detection, semen handling, or site of semen deposition. In addition to evaluation of AI technicians, it is imperative that dairy producers and AI studs provide continuing education to their technicians to offer them the greatest opportunity to succeed, which, in turn, will offer the dairy a greater opportunity to accumulate pregnant cows quickly and increase profitability.

## Acknowledgements

The heat detection accuracy research has been supported by a grant from ABS Global, Inc., DeForest, WI. The authors also thank R. Chebel, K.S. Jensen, S. Etter, and C. Johnson for technical support.

## References

- Buelow, K., S. Stewart, P. Rapnicki, and S. Godden. 1999. Reproductive performance. In: *Reneau, J. (ed.), Dairy Initiatives Newsletter*, University of Minnesota Extension Service, 8:1:1.
- Dalton, J.C., A. Ahmadzadeh, B. Shafii, W.J. Price, and J.M. DeJarnette. 2004. Effect of thawing multiple 0.5-ml semen straws and sequential insemination number on conception rates in dairy cattle. *J. Dairy Sci.* 87:972-975.
- de Vries, A., and C.A. Risco. 2005. Trends and seasonality of reproductive performance in Florida and Georgia dairy herds from 1976 to 2002. *J. Dairy Sci.* 88:3155-3165.
- DHI-Provo. 2008. Consultant zone: Regional statistics. Available at: <http://www.dhiprovo.com/consultzone.asp>
- Diskin, M.G., J.R. Pursley, D.A. Kenny, J.F. Mee, and J.M. Sreenan. 2004. The effect of deep intrauterine placement of semen on conception rate in dairy cows. *J. Dairy Sci.* 87:(Suppl. 1):257 (Abstr.).
- French, P.D., and R.L. Nebel. 2003. The simulated economic cost of extended calving intervals in dairy herds and comparison of reproductive management programs. *J. Dairy Sci.* 86:(Suppl. 1):54 (Abstr.).
- Hawk, H.W., and T.Y. Tanabe. 1986. Effect of unilateral cornual insemination upon fertilization rate in superovulating and single-ovulating cattle. *J. Anim. Sci.* 63:551-560.
- Hopkins, S.M. 1989. Reproductive patterns of cattle. In: *Veterinary Endocrinology and Reproduction*, L.E. McDonald (Ed), Lea and Fibiger, Philadelphia, PA, pp. 399-415.
- López-Gatius, F. 1996. Side of gestation in dairy heifers affects subsequent sperm transport and pregnancy rates after deep insemination into one uterine horn. *Theriogenology* 45:417-425.
- Lucy, M.C. 2001. Reproductive loss in high-producing dairy cattle: Where will it end? *J. Dairy Sci.* 84:1277-1293.
- Macpherson, J.W. 1968. Semen placement effects on fertility in bovines. *J. Dairy Sci.* 51:807-808.
- McKenna, T., R.W. Lenz, S.E. Fenton, and R.L. Ax. 1990. Nonreturn rates of dairy cattle following uterine body or cornual insemination. *J. Dairy Sci.* 73:1779-1783.

- Moore, D.M., M.W. Overton, R.C. Chebel, M.L. Truscott, and R.H. BonDurant. 2005. Evaluation of factors that affect embryonic loss in dairy cattle. *J. Am. Vet. Med. Assoc.* 226:7:1112-1118.
- Nebel, R.L., W.D. Whittier, B.G. Cassell, and J.H. Britt. 1987. Comparison of on-farm and laboratory milk progesterone assays for identifying errors in detection of estrus and diagnosis of pregnancy. *J. Dairy Sci.* 70:1471-1476.
- Nebel, R.L. and S.M. Jobst, 1998. Evaluation of systematic breeding programs for lactating dairy cows: A review. *J. Dairy Sci.* 81:1169-1174.
- Niles, D., S. Eicker, P. Rapnicki, and S. Stewart. 2001. Using pregnancy rate to monitor reproductive management. In: *Proc. 5<sup>th</sup> West. Dairy Mgt. Conf.*, Las Vegas, NV, pp. 117-121.
- Overton, M.W. 2001. Stochastic modeling of different approaches to dairy cattle reproductive management. *J. Dairy Sci.* 84:(Suppl. 1):268(Abstr.).
- Overton, M.W. 2005. Dairy cattle reproduction: Measuring efficiency and economics. In: *Proc. ABS Global and Balchem West. Dairy Mgt. Pre-Conference Symposium*, Reno, NV, pp. 1-12.
- Overton, M.W. 2007. Using reproductive records: Basics of monitoring. In: *Proc. 8<sup>th</sup> West. Dairy Mgt. Conf.*, Reno, NV.
- Overton, M.W. 2008. Economics of dairy reproduction: An application of marginality. In: *Reproduction for Profit and Success Pre-Conference Seminar, American Association of Bovine Practitioners*, Charlotte, NC.
- Peters, J.L., P.L. Senger, J.L. Rosenberger, and M.L. O'Connor. 1984. Radiographic evaluation of bovine artificial inseminating technique among professional and herdsman-inseminators using .5- and .25-mL French straws. *J. Anim. Sci.* 59:1671-1683.
- Pursley, J.R. 2004. Deep uterine horn AI improves fertility of lactating dairy cows. *J. Dairy Sci.* 87:(Suppl. 1):372(abstr.).
- Reimers, T.J., R.D. Smith, and S.K. Newman. 1985. Management factors affecting reproductive performance of dairy cows in the northeast United States. *J. Dairy Sci.* 68:963-977.
- Senger, P.L. 1999. The luteal phase of the estrous cycle. In: *Pathways to Pregnancy and Parturition*, Current Conceptions, Inc., Pullman, WA, pp. 149-166.
- Senger, P.L., W.C. Becker, S.T. Davidge, J.K. Hillers, and J.J. Reeves. 1988. Influence of cornual insemination on conception in dairy cattle. *J. Anim. Sci.* 66:3010-3016.
- Washburn, S.P., W.J. Silvia, C.H. Brown, B.T. McDaniel, and A.J. McAllister. 2002. Trends in reproductive performance in southeastern Holstein and Jersey DHI herds. *J. Dairy Sci.* 85:244-251.

Williams, B.L., F.C. Gwazdauskas, W.D. Whittier, R.E. Pearson, and R.L. Nebel. 1988. Impact of site of inseminate deposition and environmental factors that influence reproduction of dairy cattle. *J. Dairy Sci.* 71:2278-2283.



# National Heifer Supply and the Effects of Sexed Semen

Albert De Vries, Ph.D.

Department of Animal Sciences, University of Florida

PO Box 110910, Gainesville, FL 32611

Phone: (352) 392-5594, Email: devries@ufl.edu

Ray Nebel, Ph.D.

Select Sires Inc., Plain City, OH 43064

Phone: (614) 873-4683, Email: rnebel@selectsires.com

## Summary

Commercial sales of sexed semen for dairy cattle in the US started to take off in 2006. Use of sexed semen is estimated to have increased from 18,000 units per month in early 2006 to 300,000 units per month in late 2008. Because sexed semen has lower fertility than conventional semen, dairy producers have used sexed semen primarily in virgin heifers. For December 2008, we estimated that 37% of all heifers that got pregnant that month conceived with sexed semen. In that month, 2.5% of all cows that became pregnant conceived with sexed semen. Together, we estimated 12.4% more heifer calves as a result of the use of sexed semen in the cows and heifers that became pregnant that month than if conventional semen had been used. In December 2008, 7% more heifer calves were born than would be born if only conventional semen had been used. The first heifer calves conceived by sexed semen in early 2006 were starting to enter milking herds late 2008. We estimated that less than 1% of all heifers entering milking herds by the end of 2008 were conceived by sexed semen. By the end of 2009, this will be about 2% of all entering heifers and 6% by the end of 2010. The impact of sexed semen on the national heifer supply has been small, but is expected to grow.

## Introduction

Sexed semen is semen which has a modified ratio of X-chromosome (female) bearing sperm to Y-chromosome (male) bearing sperm. This modification is obtained by sorting of normal (conventional) semen that has 50% X-bearing and 50% Y-bearing sperm. Fertilization of an egg with an X-bearing sperm leads to a heifer calf. Thus, sexed semen with relatively more X-bearing sperm has a greater chance to result in a heifer calf. Dairy producers have always been interested in sexed semen because heifer calves are generally much more valuable than bull calves.

Commercialization of X-sorted sexed semen started in 2003 but sales did not take off until early 2006. Presently, all major North American A.I. companies sell sexed semen from dairy sires. Demand has been greater than the supply of sexed semen which has thus far resulted in rapid use in inseminations of all processed sexed semen for the US market. As of December 2008, the use of sexed semen has already resulted in more heifer calves being born and more heifer calves are expected to be born in the near future. In this paper we describe the estimated impact of the use of sexed semen on the national heifer supply. We also briefly describe the technology and current results with sexed semen.

## **Sorting technology**

The only repeatable technique to sort sperm for gender uses a machine called a flow-cytometer to detect varying differences in DNA content over multiple breeds from 3.6 to 4.1% between X- and Y-bearing sperm (Garner et al., 1983). Presently, all North American A.I. companies use this same technique. The first step in this procedure is to dilute sperm to a very low concentration and stain them with a harmless DNA-specific fluorescent dye. The sample is then sent through the flow cytometer at 60 mph under pressures of 40 psi. Stained sperm are aligned single-file in a fluid stream. Then cells of interest are identified at a particular droplet and sorted if classified as a cell of interest. Droplets holding the cell of interest are deflected into a catch tube. As the cells enter the laser beam profile, they emit light proportional to the amount of DNA. For the sorting to be successful, each sperm head must be precisely oriented so the DNA content can be accurately determined.

Because an X-chromosome is larger, it emits slightly more light than a Y-chromosome bearing sperm cell. Detectors measure the amount of fluorescence or light emitted and assign positive or negative charges to each droplet containing a single sperm. Charged deflector plates then split the single stream into three streams: positively charged droplets containing X-bearing sperm go one direction while negatively charged Y-bearing sperm are deflected in the opposite direction. Uncharged droplets containing dead, multiple cells in one drop or droplets with unidentified, unresolvable sperm pass straight through. This procedure separates sperm of the two sexes with approximately 90% purity (Amann, 1999).

To properly sort, sperm must be precisely oriented as they pass through the laser and fluorescence detectors in the flow cytometer. Due to the flat shape of bull sperm heads, only about 60 to 70% is correctly oriented and half of these are female. Thus, only 15% of the sperm going into the machine are recovered as viable, sexed semen. Although the 5,000 sperm of each sex sorted per second sounds like a lot, this translates into approximately 1 hour and 7 minutes of sorting to process enough semen for a standard 20 million sperm straw. Thus, due to the slow sorting speed and only 10 to 15% of the sperm entering the sorting machine are recovered as marketable product, commercialization is only possible with very low sperm numbers per straw (approximately 2 million sperm per straw). Additionally, the cost of flow cytometry equipment (approximately \$400,000 per machine) and highly skilled labor required to sort sperm dictates that sexed semen be sold at a higher price than the same bull packaged traditionally. Each machine can process approximately 12 units per hour and machine time is approximately 18 hours per day, thus each machine can process approximately 215 units per day. If we assume down time and holidays, every machine has the ability to produce approximately 63,000 units per year. The sorting technology continues to be improved with the most recent gains in sorting speed.

## **Licensing and production of sexed semen**

In the 1980's, a breakthrough in the described sex sorting technology was made by United States Department of Agriculture researchers in Livermore, CA and Beltsville, MD (Garner et al., 1983; Johnson et al., 1989). The patents for this technology were licensed to XY Inc., Fort Collins, CO, which performed a considerable amount of research during the 1990's to optimize efficiency of these sorting procedures (Seidel et al., 1999; Schenk et al., 1999). Commercialization of sexed semen in

the United States started in 2003 with a license granted to Sexing Technologies (ST). In February 2003, the first ST sexing laboratory started operations in Navasota, TX. In February 2006, a second laboratory was established in Plain City, OH at Select Sires Inc. In August 2006, a ST laboratory opened in Madison, WI and was affiliated with ABS Global. During mid-2007 a ST sorting laboratory was opened in Ithaca, NY for Genex Inc. and XY licensee in Canada for Semex Inc. In January of 2008, ST started a sorting laboratory outside of Calgary, Alberta, Canada for Alta Genetics Inc. In mid 2008, ST opened another sorting laboratory in Fond du Lac, WI. The latest ST sorting laboratory started in the fall of 2008 in Baraboo, WI for Accelerated Genetics. Presently (December 2008), all major North American A.I. companies have a ST laboratory near a production facility to sort semen with approximately 70 sorting machines processing semen 24 hours per day seven days per week.

Given the 63,000 units per year that can be produced with one machine, the 70 machines running at maximum capacity could produce approximately 4.4 million units per year. However, some of the production will be beef and maybe as much as 10% of production will be sexed semen for the international dairy market. Figure 1 shows the estimated monthly amount of sexed semen units produced for the US dairy market from January 2006 to December 2008 based on the capacity of sex sorting laboratories. Early 2006, approximately 18,000 units were produced monthly. By the end of 2008, this number had increased to approximately 300,000 units. Total sexed semen production for the US dairy market in 2008 is estimated at 2.5 million units.

Total sexed semen production from 2006 to the end of 2008 is probably equal to the projected production in 2009 if all machines are used to maximum capacity. Therefore, for the US dairy market, a total of 3.7 million units of sexed semen are expected to be produced in 2009.

### **Results with sexed semen**

Research has consistently demonstrated that the technology used to sort semen produces about 90% calves with the desired gender (DeJarnette et al., 2008). However, not every 10 inseminations result necessarily in exactly 9 heifer calves. Random chance says that in about 26% of the herds that inseminate 10 animals,  $\leq 80\%$  of the offspring will be heifer calves. Seven percent of the time,  $\leq 70\%$  of the offspring will be heifer calves. These are simple mathematical probabilities of which the dairy producer should be aware. Reality is that the current technology is consistently achieving an average of approximately 90% heifer calves when evaluated across a larger number of calvings.

Sexed semen has always been recommended for use in heifers because of the known compromise in conception rates largely due to the reduced sperm number per unit. Initial reports published from a limited number of inseminations warned of approximately a 30% reduction in conception rates in virgin heifers (Olynk and Wolf, 2006). In January of 2008, insemination and calving information were retrieved from 198 dairy herds that had used Select Sires' gender SELECTed™ sexed semen from January 2005 to January 2008. The unadjusted conception rate for 41,398 inseminations to gender SELECTed™ semen was 45%.

Across all herds, 74% of gender SELECTed™ semen was used at 1st insemination, 18% at 2nd insemination, and 8% at  $\geq 3$  insemination. The conception rate was 47%, 40%, and 34% for insemination numbers 1, 2 and  $\geq 3$ , respectively. These actual field results revealed that gender

SELECTed™ semen was achieving approximately 80% of the conventional semen conception rate (a 20% reduction in conception rates compared to unsorted semen).

### **Recommended use of sexed semen**

The optimal use of sexed semen depends on many economic and biological factors. The return on investment for the dairy producer depends on a complex interaction between the initial conception rate with conventional semen, the percent reduction in conception rate due to use of sexed semen, the price differential between sexed and conventional semen, the value differential between bull and heifer calves, and the enterprise that the extra heifers will be used for (herd replacements, to contract, etc). Most of these factors will change considerably from herd to herd, which affects the value of sexed semen to each respective producer.

There is no reliable rule of thumb that can dictate proper use across the variety of herds, cows, and economic scenarios possible. Dairy producers could use sexed semen to produce more herd replacements, to produce heifers to sell to other dairy producers, or both. Increasing replacements from within reduces the risk of introducing infectious diseases by increasing biosecurity. Sexed semen will produce more heifer calves that have lower birth weight than bull calves, and will reduce rate and cost of difficult calvings. Difficult calvings occur in approximate 1 out of every 10 calvings of first lactation heifers. With sexed semen, culling of poor performing growing heifers is more feasible, thereby avoiding losses associated with bringing them into the herd only to have them removed early in lactation. In some specialized dairy sectors such as organic dairies and herds using crossbreeding programs the value of replacements may remain significantly above the cost of rearing, making sexed semen very valuable.

Economic analyses that have included these complex interactions suggest that sexed semen is most valuable in virgin heifers, and then primarily in the first insemination, and with diminishing returns in later inseminations (Olynk and Wolf, 2006; Fetrow et al., 2007; De Vries, 2008). Sexed semen could have value in some cows if the reduction in conception rate is modest, heifer calf prices are high compared to bull calves, and the price of sexed semen is reasonable compared to conventional semen.

### **Actual use of sexed semen**

Actual use of sexed semen follows the results of the economic analyses. That means that most sexed semen has been used in heifers and then primarily in the first insemination, and little in cows. Data from the April, 2008 national genetic evaluation by USDA-Animal Improvements Laboratory (USDA-AIPL) revealed that from 2006 to April 2008, 9.2% of Holstein heifers had at least one insemination with sexed semen (Hutchison and Norman, 2009). Sexed semen was used in 6.8% of all heifer inseminations (by AI). In that same time period, they reported that 2.4% of all Holstein cows had at least one sexed semen insemination; or 0.9% of all reported cow inseminations. (Our own calculations indicated that sexed semen accounted for only 0.3% of all cow inseminations in that period). Larger herds and herds with higher production levels, and herds in the Northwest, Mideast, and Midwest used sexed semen more frequently than other herds and regions.

Actual use of sexed semen over time has been growing, as was already evident by the increasing number of sorting machines over time. The USDA-AIPL data showed that sexed semen inseminations accounted for 1.5%, 9.6%, and 14.2% of all reported inseminations in 2006, 2007, and

2008. For cows, sexed semen inseminations accounted for 0.1% (2006), 1.3% (2007) and 2.1% (2008) of all reported (AI) inseminations. (Again our estimates are lower: 0.02%, 0.2%, and 1.4%, respectively).

USDA-AIPL also reported that for heifers, 80% of sexed semen was used in the first insemination. In cows, 49% of sexed semen was used in first parity cows including 21% on first insemination. Similarly, the 198 dairy herds that had used Select Sires' gender SELECTed™ sexed semen from January 2005 to January 2008 reported that across all herds, 74% of gender SELECTed™ semen in heifers was used at the 1st insemination, 18% at the 2nd insemination, and 8% at  $\geq 3$  inseminations.

USDA-AIPL calculated that 29% of the 717 active Holstein bulls born after 1994 had their sexed semen used in the April, 2008 national genetic evaluation (Hutchison and Norman, 2009). These 211 bulls were on average slightly better than the average bull for milk yield traits (fat, protein, yield), productive life, daughter pregnancy rate, and Net Merit. They were also slightly better for somatic cell score, calving ease, and stillbirth.

Results from Select Sires Inc. of 211 dairy farms suggest that in heifers age of first insemination and age at calving was younger when sexed semen was used (DeJarnette et al., 2009). This is a result of the preferential use of sexed semen at first insemination. Cycle lengths were not affected by the use of sexed semen. Sexed semen did not affect stillbirth rates in heifers getting heifer calves, but among heifers getting bull calves (from sexed semen, a 10% chance), the incidence of stillbirths appeared higher. In all calvings resulting from sexed semen, the total incidence of stillbirth was similar as when conventional semen was used. Caution must be used when interpreting results from field data because of the preferential use of sexed semen (only heifers with good standing estrus are inseminated with sexed semen, for example). Heifer calves resulting from sexed semen appear to be completely normal.

### **Effect of sexed semen on the national heifer supply**

Figure 1 showed the timing and number of sexed semen units produced for the domestic dairy market. The produced units have been used in inseminations almost immediately after they became available. Further, the vast majority of sexed semen has been used in virgin heifers. Our estimates are that in 2006, 99% of the produced sexed semen was used in heifers. In 2007 and 2008, these percentages were 96% and 85% respectively. The remainder was used in cows. Thus, more of the sexed semen was used in cows in late 2008 than during the early commercialization in 2006, but the use was still limited. These data are the basis for the following calculations on how the use of sexed semen affects the national heifer supply.

The number of new pregnancies with heifer calves from sexed semen inseminations has increased from 7,200 in January 2006 to 112,000 in December 2008 (Figure 2). These estimates include 45% and 28% conception rates with sexed semen in heifers and cows, respectively. It also includes a small adjustment for abortions. And further, 90% of the new pregnancies are heifer calves. Because cows have lower conception rates than heifers, cows contributed only 0.6% (January 2006) to 10% (December 2008) of the new pregnancies from sexed semen.

If these same heifers and cows had conceived with conventional semen (48% heifer calves), the number of new pregnancies with heifer calves would have been approximately 3,800 in January 2006 to 60,000 in December 2008. Thus, almost half of the heifers and cows would also be carrying a heifer calf if they had been inseminated with conventional semen. These heifer calves must be

subtracted from the heifer calves from sexed semen to calculate the net gain. The monthly net gain in number of heifer calves ranges from 3,400 in January 2006 to 52,000 in December 2008. Summed over the three years (2006 to 2008), the number of extra heifer calf pregnancies due to the use of sexed semen is 630,000. Per unit of sexed semen, we got about 17% more heifer calves.

These numbers of new pregnancies with heifer calves from sexed semen need to be compared with the total number of new pregnancies with heifer calves on US dairy farms. USDA estimates available on the University of Wisconsin dairy markets website (<http://future.aae.wisc.edu>) showed the national population of dairy cows at about 9.1 million in 2006 and increasing to 9.2 million in 2008. Commercial dairy cow slaughter and death losses accounted for approximately 3.2 million cows in 2006 and 3.5 million in 2008. Average annual national cull rate (including deaths) is then 36%, which agrees with the 2007 Dairy Report from USDA (2008). Culled and dead cows are replaced by calving heifers because the national cow population is fairly constant. Thus, approximately 277,000 heifers will calve monthly (starting first parities). We also estimated that approximately 459,000 cows will calve monthly (starting second and greater parities).

Of all conceiving heifers, 3% (early 2006) to 37% (late 2008) got pregnant with sexed semen. Of the conceiving cows, 0.01% (early 2006) to 2.4% (late 2008) got pregnant with sexed semen (Figure 3). The remainder of the calving heifers and cows then became pregnant with either conventional AI or by natural service bulls, with 48% of these pregnancies resulting in heifer calves. Nationally, the total number of new pregnancies with heifer calves is approximately 370,000 per month. Sexed semen use has caused 1% (early 2006) to 12% (late 2008) more heifer calves in new pregnancies than if conventional semen has been used (Figure 4).

Figure 4 also shows when the extra heifer calves are born (births) and when they are expected to enter the milking herd as heifers themselves (entering). We assumed that 80% of heifer calves enter the milking herd as heifers 24 months after they are born. For December 2008, we estimated 12.4% more heifer calves as a result of the use of sexed semen in the cows and heifers that became pregnant. During late 2008, 7% more heifer calves were born than would be born if only conventional semen had been used. The first heifer calves conceived with sexed semen in early 2006 were starting to enter milking herds in late 2008. We estimated that less than 1% of all heifers entering milking herds by the end of 2008 were conceived with sexed semen. By the end of 2009, this will be about 2% of all entering heifers and 6% by the end of 2010.

The heifer calves from the cows and heifer that are getting pregnant with sexed semen in December 2008 will enter herds approximately in September 2011. At that time, 10% from all heifers entering milking herds was conceived with sexed semen.

### **Economic implications**

The use of sexed semen for gender selection is a reality today. Most dairy producers have used sexed semen to produce more heifers by using it at every first insemination in virgin heifers that are detected in estrus regardless of the genetic merit of the heifer. Because of high market prices for replacement heifers, high milk prices, reproductive inefficiency of dairy herds, and the shortage of heifers for replacements, sexed semen has been used to just get more heifers.

The analysis above has shown that the impact of the use of sexed semen on the availability of springing heifers has thus far been limited. There is some concern that the expected increase in the

number of heifers will promote expansion of the national cow herd, increase the supply of milk, and trigger a drop in milk prices. Future prices depend on many factors beyond the supply of heifers so predictions are quite uncertain.

In 2008, about 8,100 extra heifers will be entering milking herds as a result of the use of sexed semen. In 2009, this number is increased to 63,000 extra heifers. For 2010, our calculations show that 161,000 extra heifers are expected to enter the milking herd.

For comparison, the CWT Herd Retirement Program removed in the five years from 2003 to 2007 respectively 32,724, 50,478, 64,069, 52,783, and 0 cows from the national population. The effect of these removals has been estimated by Dr. Scott Brown from the University of Missouri to increase the milk price by \$0.05, \$0.17, \$0.42, \$0.55 and \$0.62 per cwt in each of these years ([http://www.cwt.coop/pdf/cwt\\_brochure.pdf](http://www.cwt.coop/pdf/cwt_brochure.pdf)). The effect of cow removal lasts several years; for example, the cows removed in 2006 still had an effect on the milk price in 2008 but not as great as in 2007. On average, the CWT Herd Retirement Program effect on milk prices was an increase of \$0.25 per cwt per 100,000 cows removed. This effect would continue a few years after the cows were removed. If these relationships continue to hold from 2008 to 2010, the extra heifers entering the national herd would reduce the milk price by \$0.02, \$0.16 and \$0.40 per cwt, respectively.

On the other hand, sexed semen is expected to reduce the cost of milk production. The increase in the supply of heifers likely will decrease the heifer calf price and the purchase price of springing heifers. In the longer term, heifer purchase prices would be reduced to the cost of rearing and a modest profit. This is a cost savings for dairy producers that purchase heifers. For example, a \$300 lower heifer price would equal a cost savings of \$100 per cow per year in a herd with a 33% cull rate. The \$100 savings would offset a decrease in milk price of \$0.40 per cwt in a herd with cows producing 25,000 lbs annually.

Lower heifer prices should allow for a small increase in voluntary cull rates as well (De Vries et al., 2008) which also improves farm profitability. If producers are going to cull more heavily, a slightly greater voluntary cull rate will help reduce growth of the national population, thereby reducing the growth of the milk supply and potentially avoiding a reduction in milk prices.

The value of sexed semen in the future will be to source replacement heifers from the best cows in the herd. Who do you really want your replacements from? Sexed semen provides an opportunity to advance the genetic merit of cows in the herd by selecting the best heifers or maybe even cows to be the dams of herd replacements. In conjunction with high genetic merit sires, sexed semen will produce more rapid genetic advancement than obtaining replacements from the whole herd. For this to work, the dairy must be able to rank its dams by genetic merit so sire ID is a must. Genomics testing will be another tool that producers can use to identify the gene profile of dams most eligible for sexed semen. Herds that desire to guarantee a more reliable and better quality of internally grown heifers will use sexed semen to source more heifers and improve biosecurity.

Collectively, the benefits for dairy producers appear to outweigh the possible negative effect of a small increase in the national heifer supply. The cost of milk production will likely be reduced which should benefit consumers as well.

## References

- Amann, R. P. 1999. Issues affecting commercialization of sexed sperm. *Theriogenology* 52:1441-1457.
- De Vries, A., M. Overton, J. Fetrow, K. Leslie, S. Eicker, and G. Rogers. 2008. Exploring the impact of sexed semen on the structure of the dairy industry. *Journal of Dairy Science* 91:847-856.
- De Vries, A. 2008. Sexed semen economics. Pages 67-82 in: Proceedings 45th Annual Florida Dairy Production Conference, Gainesville, FL, April 29. Available at: <http://dairy.ifas.ufl.edu/conferences/dpc.shtml>
- DeJarnette, J. M., R. L. Nebel, and C. E. Marshall. 2008. An update on the commercial application of sex-sorted semen in Holstein heifers. *Journal of Animal Science* 86 (E-Suppl 2): *Journal of Dairy Science* 91 (E-Suppl 1):459 (Abstract).
- DeJarnette, J. M., R. L. Nebel, and C. E. Marshall. 2009. Evaluating the success of sex-sorted semen in US dairy herds from on farm records. *Theriogenology* 71:49-58.
- Fetrow, J., M. Overton, and S. Eicker. 2007. Sexed semen: economics of a new technology. 24 pages in: Proceedings Western Dairy Herd Management Conference, Reno, NV, March 7-9. Available at: <http://www.wdmc.org/proceed.htm>
- Garner, D. L., L. A. Johnson, S. Lake, N. Chaney, D. Stephenson, D. Pinkel, and B. L. Gledhill. 1983. Quantification of the X- and Y-chromosome-bearing spermatozoa of domestic animals by flow cytometry. *Biology of Reproduction* 28:312-321.
- Hutchison, J. L., and H. D. Norman. 2009. Characterization and usage of sexed semen from US field data. *Theriogenology* 71:48.
- Johnson, L. A., J. P. Flook, and H. W. Hawk. 1989. Sex preselection in rabbits: live births from X and Y sperm separated by DNA and cell sorting. *Biology of Reproduction* 41:199-203.
- Olynk, N. J., and C. A. Wolf. 2006. Expected net present value of pure and mixed sexed semen artificial insemination strategies in dairy heifers. *Journal of Dairy Science* 90:2569-2576.
- Schenk, J. L., T. K. Suh, D. G. Cran, and G. E. Seidel Jr. 1999. Cryopreservation of flow-sorted bovine spermatozoa. *Theriogenology* 52:1375-1391.
- Seidel, G. E. Jr, J. L. Schenk, L. A. Herickhoff, S. P. Doyle, Z. Brink, R. D. Green, and D. G. Cran. 1999. Insemination of heifers with sexed sperm. *Theriogenology* 52:1407-1420.
- USDA, 2008. Dairy 2007, Part III: Reference of Dairy Cattle Health and Management Practices in the United States, 2007. USDA-APHIS-VS, CEAH. Fort Collins, CO. #N482.0908. Available at: <http://nahms.aphis.usda.gov/dairy/index.htm>

Figure 1. Estimated amount of produced sexed semen units for the US dairy market from January 2006 to December 2008. Almost all produced units are used in inseminations within a few months.

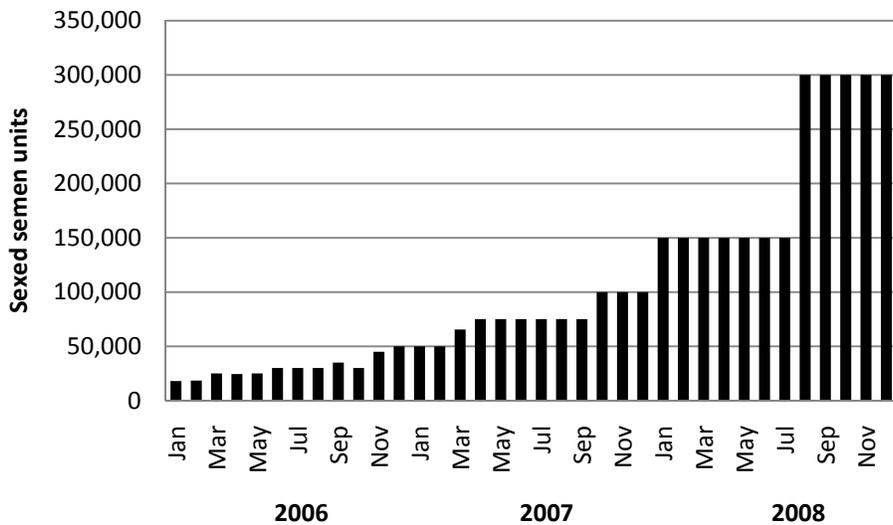


Figure 2. Number of new pregnancies with heifer calves per month in those heifers and cows inseminated with sexed semen from January 2006 to December 2008.

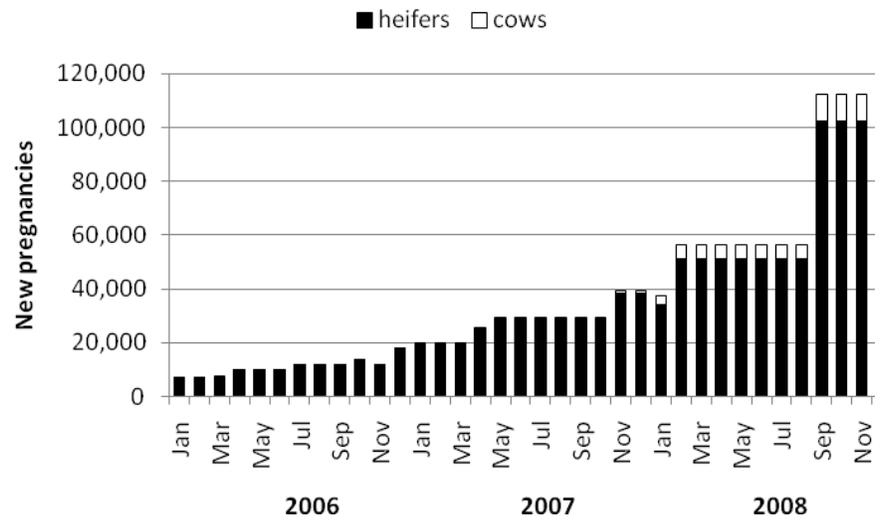


Figure 3. Percentage of new pregnancies with heifer calves in the national population (heifers and cows) that result from inseminations with sexed semen from January 2006 to December 2008.

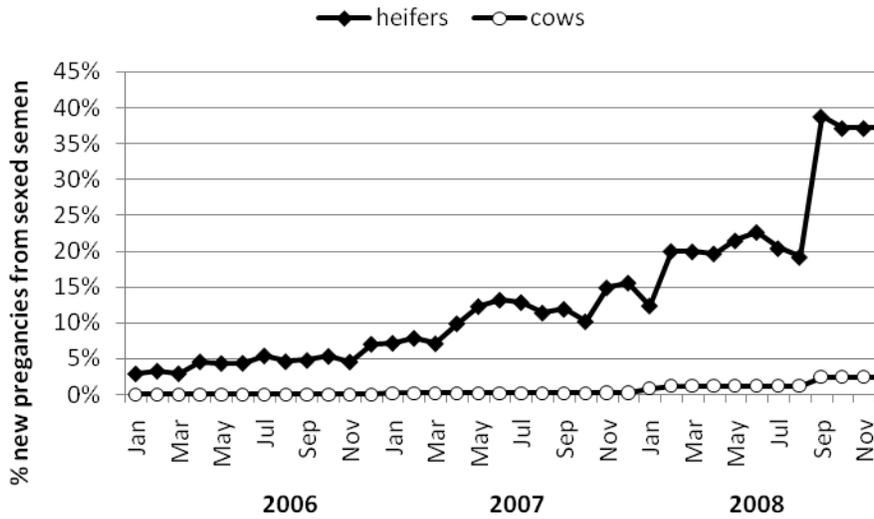
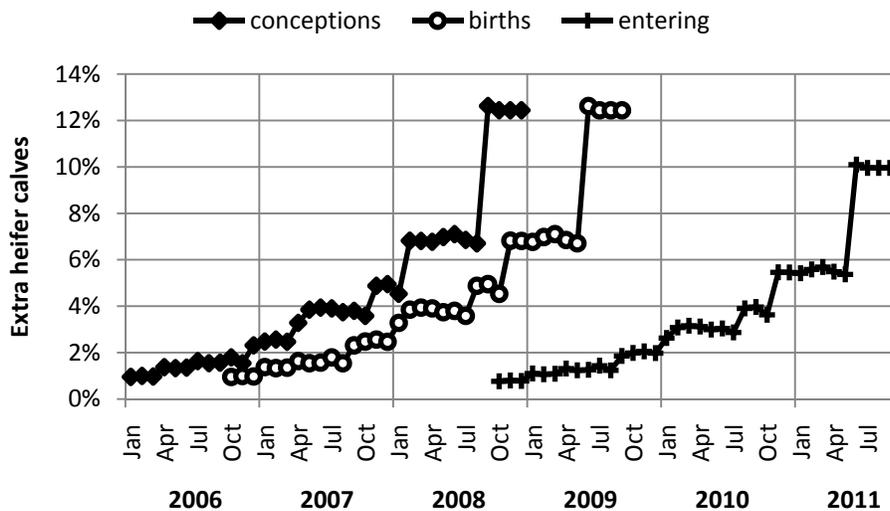


Figure 4. Percentage of extra heifer calves in the national population (heifers and cows) that resulted from inseminations (conceptions) with sexed semen from January 2006 to December 2008. These heifer calves are born (births) 9 months after conception and enter herds 24 months after they are born (entering).



# Adult Dairy Cow Mortality

Franklyn Garry DVM, MS  
Colorado State University  
300 West Drake Road  
Fort Collins, CO 80523  
Phone 970-297-0371  
Email [fgarry@colostate.edu](mailto:fgarry@colostate.edu)

## How big of a problem is dairy cow mortality in the US?

### Key Points

- The frequency of adult dairy cow mortality appears to be increasing
- Cow mortality is important both economically and as an indicator of animal well-being

Mortality rates in the dairy industry are much higher than those in the cow calf or feedlot industries. Death losses have not been studied very intensively in the dairy industry. Estimates of these death losses are quite variable. Unless they are focused on monitoring cow deaths, dairy producers may underestimate the amount of adult cow death loss on their operations. The USDA:APHIS:VS National Animal Health Monitoring System (NAHMS) Dairy 2007 survey reported that 5.7% of dairy cows die on-farm across the country each year, an increase from 4.8% of the January 2002 inventory, and 3.8% of the January 1996 inventory. These rising mortality levels represent a problem both in terms of financial losses and compromised animal welfare.

Information from computerized dairy record systems suggests that mortality rates have continually increased over the last 10 years. In some states, adult cow mortality exceeds 10% per year. Very few formal studies have focused on this issue, yet dairy cattle death losses are an extremely important problem. Not only are these losses an economic disaster, they also represent very substantial problems with animal well-being. This would seem to be an issue requiring substantial veterinary attention, but at present it does not appear that veterinarians or producers have the information required to manage the problem appropriately.

## Why do dairy cows die?

### Key Points

- Dairy mortality problems are related to culling, disease, and injury problems
- Analyses of specific reasons for increasing mortality are not available
- Producer assessments of mortality causes are often inaccurate and do not provide information that can be used to decrease the problem

Most studies of dairy cow mortality have come from outside the United States. The US studies on this issue have been primarily focused on culling and herd turnover rates rather than death losses per se. The 2007 national survey of dairies in the US showed that approximately 23.6% of dairy cows left herds permanently during 2007, and that approximately 5.5% of these cows were sold to other dairies, while 94% were culled (i.e. sold and not returned to milk production, sent for slaughter). The reasons cows were culled included reproductive failure (26.3% of culled cows), mastitis and udder problems (23%), lameness or injury (16%), other disease (3.7%), and poor milk production not related to these other problems (16%), while other miscellaneous reasons accounted for about 8% of culling. Therefore, on average, the overwhelming majority of dairy cows leaving farms are not fit for sale as dairy production animals, and approximately 50% of these cows leave because of disease or injury problems rather than being selectively removed because of low fertility or milk productivity.

Adult cow death losses appear to be attributable to reasons similar to those for culling cows. A recent literature review identified 19 studies between the years 1965 and 2006 that focused on dairy cow mortality in countries with relatively intensive dairy production. While 10 of the 19 studies provided information about causes of death, none of the diagnoses were founded on necropsy evaluation. Only a single study discriminated between cows that were euthanized or died unassisted. Recorded causes of death were relatively uniform across studies and were categorized as: accidents, calving disorders, digestive disorders, locomotor disorders, metabolic disorders, udder/teat disorders, other known reasons, and unknown reasons. The NAHMS Dairy 2007 survey recorded causes of death similarly to those established through the literature review, documenting the percentage of cow deaths due to: euthanasia due to lameness or injury (20.0%), mastitis (16.5%), calving problems (15.2%), respiratory problems (11.3%), scours, diarrhea, or other digestive problems (10.4%), lack of coordination or severe depression (1.0%), poison (0.4%), other known reasons (10.2%), and unknown reasons (15.0%).

Cause of death entered in dairy record systems is often based on producer assessment and diagnosis. It appears that dairy veterinarians are minimally involved in the diagnosis of cause of death, and relatively few U.S. dairy operations perform necropsies in an effort to determine the cause of cow death. The NAHMS Dairy 2007 study reported that necropsies were performed on only 13% of operations and only 4.4% of cow deaths received a thorough postmortem examination. Therefore, to date virtually all studies of dairy cow mortality are based on producer assessment rather than veterinary diagnosis. Determining the cause of death provides invaluable information for preventing future deaths and improving herd health.

At present no specific reason has been identified for the increase in dairy cow death rates. Producers and veterinarians appear to have attributed increasing death rates to a variety of causes. Some have questioned whether the new federal regulations regarding down dairy cows and neurologic disease may have artificially increased recorded death rates. While this will contribute to recorded mortalities, death rates were increasing prior to the implementation of this rule. Furthermore, if euthanized down cows represent more than a small fraction of dairy mortalities, we need to ask why so many cows need to be euthanized. Others have suggested that specific disease problems such as hemorrhagic bowel disease may be increasing death rates, but the increased mortality rates far exceed the incidence of any specific disease problem. Any conjectures on the cause of increased mortality are difficult to validate without specific diagnoses.

Dairy record systems appear to be an unreliable source of information concerning cause of death. We have been studying the phenomenon of dairy cow mortality over the last couple of years. Our

findings suggest that dairy producer assessment of the proximate cause of death is inaccurate approximately 50% of the time. Our results also show that there are multiple causes of dairy cow death. Mortalities tend to occur much more frequently in the early part of lactation, coincident with increases in other health problems. Increased disease rates on dairies appear to be closely related to increased death rates. It seems reasonable to suggest that numerous health problems in dairy cows are not recognized early enough or not treated properly to promote an optimal outcome. Furthermore, without good descriptors and records of the reasons that cows die, preventive measures that should decrease disease and death are not modified or improved to address the problem.

### **What can be done to decrease dairy cow deaths?**

#### **Key Points**

**-Some features of modern dairy systems may result in increasing mortality**

**-Necropsy is an underutilized tool on US dairies**

**-Dairy recording systems must be modified to capture information that can direct health management improvements**

Most decisions in a low-cost production dairy model are made with input cost as the primary driving force, and potential negative impacts on the animals in the production system are seen as problems that must be managed as a consequence. For example, it is common that large scale expansion of a dairy will capture production cost efficiencies, but often with the caveat that expansions are accompanied by substantial problems with animal health. During the time that large numbers of animals are being imported to the herd it is routine that disease introduction is occurring. Numerous animal health problems are prevalent and even increase with time. Because there are compelling reasons for dairies to expand, there is a real need for the dairy industry and dairy veterinarians to reevaluate dairy management systems with a focus on optimum animal health.

An overview of the health challenges faced by dairy cows needs to recognize that some changes in the modern dairy industry may result in systematic problems with animal care. The labor force on most dairies is primarily composed of low wage workers without extensive, preexisting dairy cow management skills. The ability of dairy personnel to adequately identify disease in individual animals and respond with prompt individual animal attention is limited by the extent of their experience and training. The overwhelming majority of sick cows on dairies are identified, diagnosed, and treated by farm workers rather than veterinarians. Poor outcomes could be an issue of poor clinical disease management in addition to any preexisting problems with cow physiology. Furthermore, record keeping systems are not focused on assessment of health challenges or causes of cow health problems. While these systems are very good at generating 'to-do' lists and monitoring cow production and cow status in the herd, they are not designed to assess cause and effect of health problems. Therefore, most producers do not have good access to the information they need to monitor health performance and to identify effective management changes that would improve cow health outcomes. Components of a program for decreasing dairy mortality would include education of the workers in the system, monitoring of processes that are used, and analysis of outcomes to identify trends.

Farm necropsy examinations should be an invaluable tool to help assess cause of adult cow death. Necropsy of dead animals to assess and monitor cause of death is rarely performed on dairies. This is in sharp contrast to other intensive livestock management systems, including poultry, swine, and feedlot enterprises where necropsy monitoring is routine. Most dairy veterinarians focus considerable effort on dairy reproduction, but little time on mortality evaluation. This presents a very significant liability to the dairy industry because efforts to effectively decrease mortality losses are hampered by a lack of monitoring and information that provide accurate assessment of the problem. We believe that dairy workers could be trained to more effectively monitor death losses, and to perform on-farm necropsy examinations in consultation with veterinarians when the veterinarian cannot be present to perform the examination on a freshly dead carcass. We have presented this recommendation to producer groups and produced an on-line training program for that purpose on our website at [http://www.cvmbs.colostate.edu/ilm/outreach/necropsy/\\_notes/INDEX.HTML](http://www.cvmbs.colostate.edu/ilm/outreach/necropsy/_notes/INDEX.HTML). Very few producers or veterinarians have pursued this approach, attesting to the notion that monitoring actual cause of death has not been seen as a valuable pursuit.

Necropsy examinations will provide good information, but we also need to develop new recording systems that allow the necropsy results to be recorded as usable information. On their own, necropsy diagnoses provide great detail about the specific cause of death, but do not necessarily provide information about why that specific cause occurred. Therefore necropsy information needs to be combined with other historical information about the affected animals to help direct management changes. Our studies suggest that at least 50% of cow death losses are attributable to causes that could be mitigated with proper management.

Because of the complex nature of dairy management systems a variety of causes are responsible for high disease and mortality rates, with different rates of occurrence on different operations. The wide range of lactational incidence risk for common diseases (milk fever: 0.03%-22.3%, RP: 1.3 – 39.2%, metritis: 2.2-37.3%, ketosis: 1.3-18.3%, LDA: 0.3-6.3, lameness: 1.8-30%) attests to the complexity of the system. To adequately address such a complex problem requires more accurate information about current losses, followed by management alterations that address the underlying problems. This will require changing the nature of information used in dairy management systems. An example of mastitis prevalence can illustrate this point. The specific infectious organism that causes a clinical mastitis episode can have a dramatic impact on outcome, and appropriate preventative or therapeutic measures need to be tailored to the specific cause, e.g. gram negative vs. gram positive, environmental vs. contagious, *Escherichia coli* vs. *Staphylococcus aureus*. Assessments and record systems that track “mastitis” without identifying other specific details do not provide sufficient information to promote effective interventions. Similarly, monitoring death losses with generic terms such as “lameness” or “mastitis” and performing this monitoring on the basis of presumption will not allow correction of management problems that may underlie the death.

There will not be a single simple answer to the problem of high mortality on dairies. Steps toward managing this challenge will require recognizing and defining the problem, improving information systems to provide details necessary to take action, and monitoring appropriate metrics that promote ongoing attention to management corrections.

# What's the connection between animal diseases and consumers?

William Sicho  
School for Global Animal Health  
Washington State University  
P.O. Box 647060  
Pullman, WA 99164  
509-335-7495  
[wmsicho@vetmed.wsu.edu](mailto:wmsicho@vetmed.wsu.edu)

## What is a consumer?

Consumers are individuals and households (other demographics might be villages, enterprises, cooperative groups) that use goods or services. In the broadest terms, consumer's relationship to the same product may range from necessity to discretionary and its availability dear to abundant. This range is absolutely true for global consumers of animal products. The impact of animal disease on consumers is very conditional on where in the world you live and how you make your living.

### Agriculture Labor Force (percent of total labor force) 2004

From Earth Trends based on data from International Labor Organization and FAO

Region	%	High	Low	
World	43.1			
Asia	55.4	93.6	0.1	Bhutan, Singapore
Central America	21.8	60.2	1.8	Haiti, Puerto Rico
Europe	7.5	45.6	0	Albania, Monaco
Middle East	30.3	65.6	0.9	Afghanistan, Qatar
North America	1.9	3.4	1.8	Greenland, US
Oceania	19.4	72	4.3	Papua, Australia
South America	16	43	6.9	Bolivia, Venezuela
Sub Saharan Africa	60.5	90.1	8.3	Rwanda, South Africa

The direct significance of agriculture on people's daily livelihood is reflected in this table. Countries and regions with significant portions of their populations directly involved in agriculture have a more visceral connection to the health of animals. These countries and regions have lower per capita income and agriculture tends to be subsistence and does not generate much if any income. Animal disease is part of daily life and endemic disease is a continual challenge to putting food on the table. Zoonotic diseases in countries where a major portion of the population are subsistence farmers are an important issue. Diseases such as bovine tuberculosis and brucellosis are real and common threats to the human population in these regions. As an example, it is estimated that 85% of cattle and 82% of humans in Africa live in areas where bovine TB is prevalent or only partially controlled. It is a common practice in these regions to drink unpasteurized milk. In Africa, TB is a significant public health disease and is increasingly found in conjunction with AIDS. The epidemiology of human cases of bovine TB in Africa is uncertain since there are few laboratories capable of differentiating

human and bovine TB. Endemic animal diseases in these regions including tick borne and viral diseases have an impact on productivity and this is likely reflected in the following tables.

### **Calorie Supply per Capita from Animal Products 2002**

From Earth Trends based on data from FAO

<b>Region</b>	<b>kCal/person/day</b>	<b>High</b>	<b>Low</b>
World	468.3		
Asia	384	893.7	67.9
Central America	493.6	906.8	145.3
Europe	922.5	1349.7	391.4
Middle East	309.1	963.5	245.6
North America	1038.3	1047	582.6
Oceania		1062.5	169.8
South America	603.4	894.4	336.1
Sub Saharan Africa	148.9	484.8	33.9

### **Meat Production per Capita (Kg/person) Commercial and Home 2006**

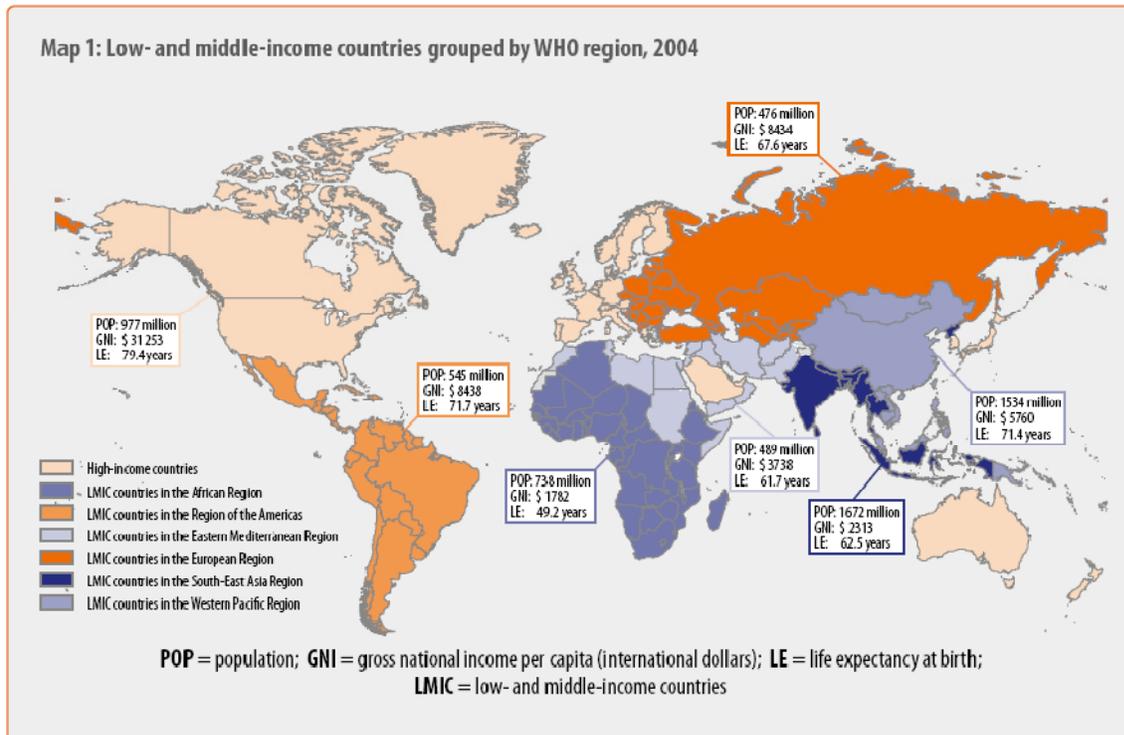
From Earth Trends based on data from FAO

<b>Region</b>	<b>Kg/person</b>	<b>High</b>	<b>Low</b>
World	41.39		
Asia	30.11	79.02	2.9
Central America	40.67	59.82	4.99
Europe	70.12	378.24	13.1
Middle East	22.3	110.34	6.29
North America	135.82	137.92	0.33
Oceania	173.68	349	2.44
South America	84.66	303.67	9.69
Sub Saharan Africa	11.81	45.1	1.15

The correlation between regions with high level of subsistence farms and relatively low meat productivity per capita and consumption of meat suggest an important linkage in the prevalence of disease in these regional herds.

In the map below, the regions of the world are demarcated on the basis of income level. Evaluation of the map and the previous tables shows that the regions of high income have very low percentage of the population that is involved with agriculture. In general, less than 10% of the population is directly involved with agriculture. In these regions, trade is a significant source of revenue within the region and most of the diseases that plague the lower income countries are tightly controlled. Bovine

TB is rare and because of pasteurization is virtually non-existent as a public health concern. Productivity is highest in these countries and in the main there is more production than consumption. It is estimated that there are 2800 Kcal from overall food that is available in the world per person. In the high income countries approximately 1/3 of the total calories are animal-derived protein compared to 1/8<sup>th</sup> or less in low income countries.



From the Global Burden of Disease, 2004 World Health Organization

For the high income regions, there is little involvement of the general population in food animal production. As a result, the populations in these regions are consumers in the common meaning of the word, users of product and goods, i.e. they purchase products. For these regions, animal disease is not a general consumer concern. If there is an impact it is on availability and price which is felt indirectly at the cash register. In these regions (as in all regions) epidemic disease is a devastating event for the producer (who carries nearly all the burden), but for the general population usually only represents an allocation of resources from other sources to address the problem. Even in significant outbreaks such as Exotic Newcastle Disease in southern California in 2002-2003, where the cost of eradication was \$170 million paid for by the consumer (taxpayer), but had only modest impact on the cost of product.

More significant to the consumer in regions of high income are diseases that have modest or no impact on the health of food animals, the food and waterborne diseases. Most of these diseases cause non-life threatening conditions, mainly diarrhea. In people, these diseases are not significant causes of mortality but are the most common reported disease in high income regions. While the food and waterborne diseases are not likely to be less common in other parts of the world (and evidence suggests they may be much higher), their significance to the consumer is small given other challenges such as securing sufficient food. Other animal disease issues relate to welfare of animals.

Diseases that cause distress to animals or appear to be diseases of management (or mismanagement) can generate a great deal of concern. Downer cow syndrome and the publicity surrounding animals being dragged to slaughter played a role in legislation mandating food animal production practices in the 2008 election cycle. The controversy during the FMD outbreak in Great Britain in 2001 over disposal and slaughter of 4 million animals ended the careers of politicians because of consumer outcry. Finally, the rise of organic and 'natural' meat and dairy products is a direct reflection on a consumer belief that large production units create unhealthy animals and consequently receive antimicrobials and hormones to mask management-induced issues.

The significance of animal disease in food production to the consumer is very much tied to the relationship that the consumer has with animal production. While the issues that consumers are addressing are different whether as a subsistence farmer or a consumer in the marketplace, consumers are affected by animal disease and impact how animal production is conducted.

# On-Farm Culturing for Better Milk Quality

Pamela Ruegg<sup>1</sup>, Sandra Godden<sup>2</sup>, Alfonso Lago<sup>2</sup>, Russ Bey<sup>2</sup>, Ken Leslie<sup>3</sup>  
University of Wisconsin, Madison, Wisconsin<sup>1</sup>  
University of Minnesota, St. Paul, Minnesota<sup>2</sup>  
University of Guelph, Guelph, Ontario<sup>3</sup>

## Take Home Messages

- Use of on-farm culture systems to direct mastitis therapy can result in reduced antibiotic usage & less discarded milk without changing the probability of achieving treatment success
- The accuracy of on-farm culture is dependent on the ability of milking personnel to collect & process a sterile milk sample
- When performed properly, on-farm culture systems are about 80% accurate.

## Introduction

Mastitis is a bacterial infection of the udder that occurs in both a subclinical and clinical state. Wisconsin dairy herds participating in a milk quality improvement program (n = 181) reported that clinical mastitis occurred in 6-8 cows per 100 milking cows per month and they estimated that the partial direct cost of each case exceeded \$91.00 (USD) (Rodrigues et al., 2005). About 60% of the direct cost was milk discarded and a further 20% was the actual cost of drugs. Additional losses caused by subclinical mastitis were estimated to be about \$150 (USD) per cow per year (Rodrigues et al., 2005). Treatment of mastitis accounts for most antibiotic usage on dairy farms. In a recent Wisconsin study, milking cows received approximately 6 doses of antibiotics per year and 80% of the usage was related to mastitis control (Pol and Ruegg, 2006).

The goal of dairy farms is to sell milk. Reduced milk production due to subclinical infections is considered to be the greatest loss associated with mastitis but for many large herds, costs of discarded milk can be significant. The typical milk discard period after a case of clinical mastitis (including treatment & withdrawal time) is about 6 days. If a 1000 cow dairy herd experiences a 6% mastitis treatment rate per month that herd would discard approximately 360 cow-days worth of milk each month (60 cases @ 6 days milk discard). At 80 lbs/cow/day milk yield and \$15.00/cwt milk, the discarded milk would be valued at \$4,320 per month or about \$52,000 per year. In this scenario, each additional day of milk discard will add another \$8500 per year in discarded milk costs. It is clearly beneficial for farms to develop mastitis treatment protocols that include efficacious treatments but also limit the period that milk will be discarded.

Successful treatment of mastitis is dependent on early detection and proper diagnosis (Erskine et al., 2003). The probability of a successful treatment outcome is based on both cow and pathogen factors (Ruegg, 2004). It is not possible to identify the pathogen without submitting milk samples for microbiological examination (“culturing”). The purpose of this paper is to provide an overview of how to set up an on-farm milk culture (OFC) system and use the results to make economically beneficial treatment decisions.

## Historical Use of Milk Culturing on Dairy Farms

Virtually all mastitis experts recommend the use of milk culturing to direct mastitis control programs but few farmers extensively use a culturing program (Hoe and Ruegg, 2005; Table 1).

Table 1. Frequency of submitting samples for culturing by Wisconsin Dairy Farmers

Question	Percent of responders				Overall
	<50 Cows	51-100 Cows	101-200 Cows	>200 Cows	
Number of Herds	279	202	42	37	
Frequency of submitting milk samples for culture (n = 547)					
All or some clinical cases	28%	33%	50%	70%	34%
Some or most cows with high SCC	28%	24%	23%	30%	27%
Some or all fresh cows	16%	13%	12%	25%	15%
Rarely submit milk cultures	56%	49%	45%	28%	51%

Diagnostic tests (such as milk cultures) are most useful when results are closely linked to management decisions. Most traditional technologies, (such as submission of milk samples for culture) require sending milk samples to a remote laboratory. These methods have been criticized as too slow for on-farm decision making. Anecdotal data suggests that farmers haven't adopted milk culturing because they don't know how to use the results or recognize the economic value of the decisions that are made as a result of the test. Results of milk culturing can be very useful to identify mastitis pathogens and make management decision about treatment, culling, segregation and disease prevention. The development of OFC has provided a way to rapidly link test results to important management decisions. A recent survey of 134 WI dairy herds indicated that about 15% were performing using OFC as part of their mastitis treatment protocols (Hohmann and Ruegg, 2007, unpublished). The use of OFC results to define treatment protocols gives farmers the opportunity to make better treatment decisions and reduce costs associated with milk discard (Neeser et al., 2006).

## Current Concepts of Effective Mastitis Treatments

Mastitis treatment goals usually include prevention of systemic illness and rapid return of milk to a saleable state. Effective treatment protocols include evaluation of cow specific risk factors (such as age and history of previous cases) and are dependent on knowledge of the likely pathogen. In general, intramammary treatments are necessary for mastitis caused by Gram positive pathogens but may not be needed for cases caused by Gram negative pathogens or cases for which the cow's immune system has successfully killed the bacteria (many culture negative cases). The basic principle of OFC is to limit use of antibiotics and to provide therapy for a sufficient duration. The objective is to minimize antibiotic usage (and minimize milk discard) without reducing expected therapeutic cures.

It is well known that the probability of cure is highly influenced by the characteristics of the pathogen. Therapeutic cure rates for several mastitis pathogens (yeasts, pseudomonas, mycoplasma, prototheca etc.) are essentially zero. Likewise, it is not considered cost-effective to treat clinical mastitis in cows that are chronically infected with *Staph aureus* because cure rates are quite low and, in most instances, when the clinical symptoms disappear the infection has simply returned to a

subclinical state. Effective cure of cows infected with *Staph aureus* are strongly related to the duration of subclinical infection. In one study, bacteriological cure rates for chronic (> 4-weeks duration) *Staph aureus* infections were only 35% compared to 70% for newly acquired (< 2-weeks duration) infections (Owens, et al., 1997). Cure rates for mastitis caused by *Staph aureus* have been shown to decrease with age (from 81 % for cows  $\leq$ 48 months of age to 55% for cows  $\geq$ 96 months), the number of infected quarters (from 73% for 1 infected quarter to 56% for 4 infected quarters) and increasing SCC (Sol et al., 1997). Treatment of clinical cases of *Staph aureus* may be successful for young cows, in early lactation with recent single quarter infections but should not be attempted for chronically infected cows.

In general, duration of antibiotic treatment is kept as short as possible to minimize the economic losses associated with milk discard. The appropriate duration of antibiotic treatment for clinical mastitis has not been well-defined and varies depending on the causative pathogen. There is considerable evidence that extended administration of antibiotics increases cure rates for pathogens that have the ability to invade secretory tissue (*Staph aureus* and some environmental Streps). For example, the bacteriological cure rates for subclinical mastitis caused by *Staph aureus* treated with intramammary ceftiofur were 0 % (no treatment), 7% (2 days), 17% (5 days) and 36% (8 days) (Oliver et al., 204). Therefore, for mastitis caused by invasive pathogens, the duration of therapy should be 5 to 8 days. However, the usage of extended duration therapy to treat pathogens that infect superficial tissues (for example coagulase negative staphylococci or Gram negative pathogens) has not been demonstrated to improve treatment outcomes and cannot be recommended because of the unnecessary cost associated with milk discard.

Use of intramammary antibiotics to treat animals experiencing mild or moderate coliform mastitis has been questioned because of the high rate of spontaneous cure and low efficacy of most antibiotics for Gram-negative organisms (Pyörälä, et al. 1994; Roberson et al., 2004). In a recent study that examined outcomes of mild and moderate cases of clinical mastitis, there were no significant differences in the number of days of abnormal milk or in the bacteriological cure rate between cases caused by Gram positive (n = 75) or Gram-negative pathogens (Hoe and Ruegg, 2005) even though the Gram-negative pathogens did not receive an appropriate therapy.

### **Use of On-Farm Culturing to Make Mastitis Treatment Decisions**

The use of an on-farm culture program depends on adoption of a severity scoring system. Use of a 3-point scale based on clinical symptoms is practical and easily understood. This system can be simply recorded and can be an important way to monitor detection intensity (Table 2). When using a 3-point scale, most herds should expect that severity score 3 cases will not exceed about 20% of total clinical cases (Table 2). Animals with severity score 3 cases *are not eligible* for delayed therapy based on results of on-farm culturing. This would leave 80% of the cases eligible for participating in treatment based on results of an OFC system.

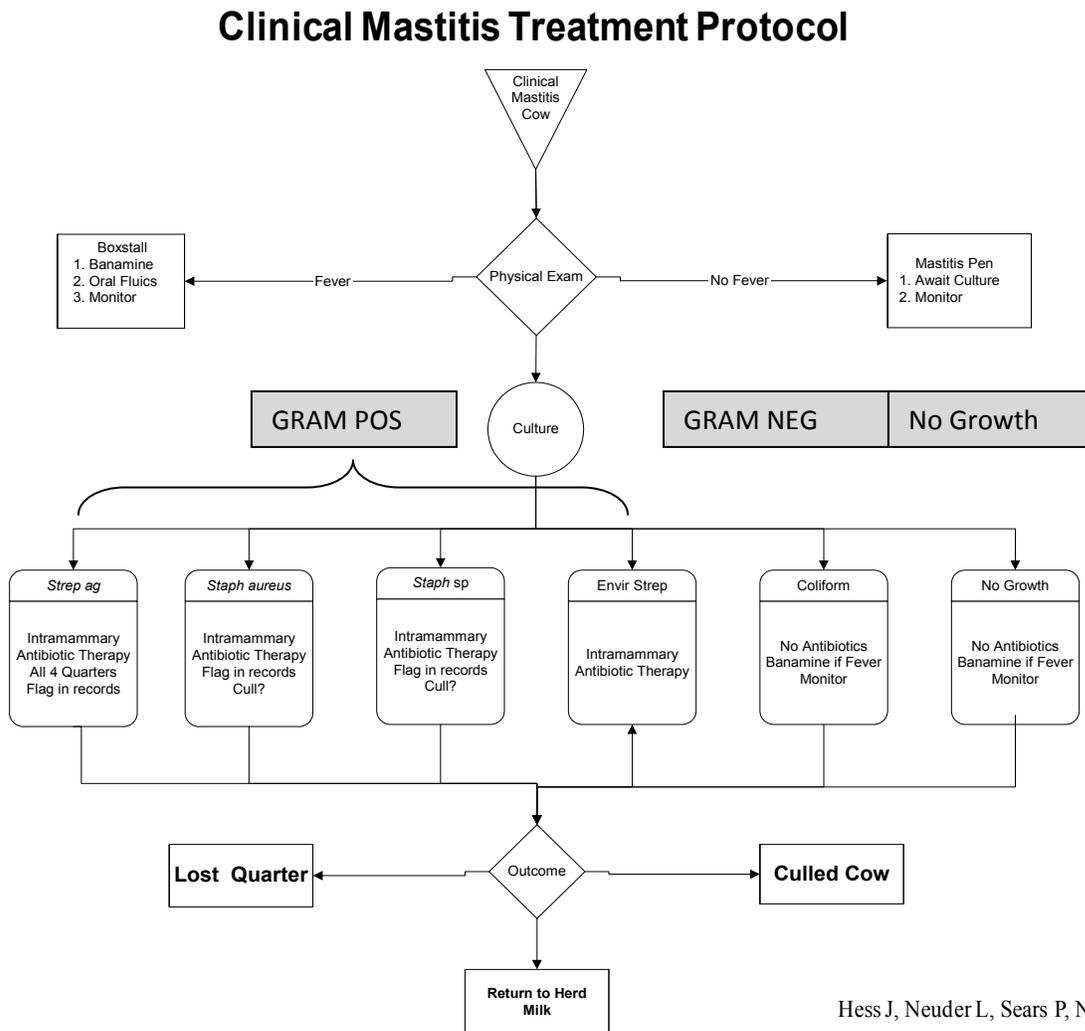
Table 2. Expected severity scores for clinical mastitis

Severity Score	Clinical Symptom	Study 1 <sup>1</sup> N = 686	Study 2 <sup>2</sup> N = 169	Study 3 <sup>3</sup> N = 212	Coliform cases only <sup>4</sup> N = 144
1	Abnormal milk only	75%	57%	52%	48%
2	Ab.milk & abnormal udder	20%	20%	41%	31%
3	Ab.milk, Ab. Udder & sick cow	5%	23%	7%	22%

<sup>1</sup>Nash et al., 2002; <sup>2</sup>Oliveira & Ruegg, 2008; <sup>3</sup>Rodrigues et al., 2008; <sup>4</sup>Wenz et al., 2001 (different but equivalent scoring system used)

As dairy herds have increased in size and developed specialized labor forces, mastitis treatment plans that include the use of OFC have been developed (Figure 1; Hess, et al., 2003). Upon diagnosis of a clinical case of mastitis, the cow is rapidly assigned a severity score and a milk sample is obtained. After severity scoring & collection of the milk sample, the eligible cows (severity scores 1 & 2) are sent to a hospital pen for monitoring and to ensure that abnormal milk is discarded. The milk sample is used to set up an OFC and no antibiotic treatment is given until results of the OFC are known (generally 24 hours). After 24 hours, the culture plate is read and, based on the results, a treatment protocol is assigned. Typical decisions that are made as a result of the OFC results include the decision to use an intramammary antibiotic, use a drug that has greater activity against Gram negative bacteria, extend the duration of treatment, or to withhold antibiotic treatment and discard milk until the cow's immune system has successfully eliminated the infection.

Fig. 1. Example of an early culture based treatment protocol (adapted from Hess et al., 2003)



### Methods of On-Farm Culturing

Methods used for OFC are not as rigorous as the methods used in most veterinary diagnostic laboratories. In a diagnostic laboratory, a small inoculum of milk is placed on media that contains nutrients for bacterial growth and the inoculated plate is placed in a warm, humid environment. After 24-48 hours, the plates are examined for growth and the bacteria are identified using a variety of specific test methods that depend on the observable characteristics of the bacteria. Implementation of OFC is similar and relatively easy. Producers dip a sterile cotton swab into the milk sample then apply it over the surface of a selective growth media. The plate is incubated in an on-farm incubator at 37 °C and is read at 24 hours. If no growth is observed, plates are re-checked after 48 hours then discarded. Some mastitis pathogens (*Mycoplasma* and others) require special environments and media and will not be detected by most OFC systems. If these pathogens are

suspected, milk samples should be submitted to a diagnostic laboratory that has experience growing these pathogens.

Methods and principles of OFC have been described (Godden et al., 2007), but, in general, OFC methods use laboratory shortcuts to make a rapid, provisional diagnosis of the bacterial cause of mastitis. The most basic method of OFC is to use selective medias to differentiate mastitis caused by Gram positive versus Gram negative bacteria. This method may be appropriate when contagious mastitis is considered unlikely (very few infections caused by *Staph aureus* or *Mycoplasma spp.* mastitis). The typical management decision linked to the results is use of intramammary antibiotics to treat mastitis caused by Gram positive bacteria in contrast to no administration of antibiotics if the diagnosis is Gram negative bacteria or no growth. Other selective medias can be used to make more sophisticated diagnoses.

Typical common medias used in OFC include: 1. blood agar – a non-selective media upon which most mastitis organisms will grow; 2. MacConkey agar – selective for Gram-negative organism growth; 3. TKT agar – selective for Streptococci growth; 4. Baird-Parker or KLMB media – selective for Staphylococci spp. (Ruegg, 2005). One commercial OFC system, the Minnesota Easy Culture System II (University of Minnesota. St. Paul, MN), offers two different types of selective culture media. The Bi-plate system is a plate with two different types of agar: MacConkey agar on one half selectively grows gram-negative organisms, while Factor agar on the other half of the plate selectively grows gram-positive organisms (Staphylococci and Streptococci). Alternately, the Tri-plate system is a plate with three different types of agar: in addition to including MacConkey agar (gram-negative growth) and Factor agar (Gram-positive growth), it also includes a section of MTKT agar which is selective for Streptococci.

Several studies that have evaluated a variety of selective medias have indicated that OFC systems appear to be about 80% accurate in differentiating Gram positive and Gram negative pathogens (Hochhalter et al., 2006, Lago et al., 2006, Pol, et al., 2009. Rodrigues, et al., 2009). The use of OFC to make more specific pathogen diagnoses is not as accurate and requires additional training of personnel. We recently compared several OFC systems for ease of use, rapidity of results, and agreement with outcomes derived from standard NMC procedures. In the first part of our study, we used 48 quarter milk samples that had been frozen before plating. The milk samples were plated using 3 different systems of OFC (PetriFilm Staph Express, Easy Culture and Quad Plates) and were compared to results of standard NMC procedures (NMC, 1999). The plates were assessed at 12, 24, and 36 hours by an experienced milk quality laboratory technician and a student intern with very little experience with milk samples. Diagnosis was not possible for any system at 12 hours of incubation. After 24 hours of incubation, somewhat variable results were observed, especially for the PetriFilm™ method. Compared to the standard NMC method, observed agreement was 63% (PetriFilm™), 80% (Easy Culture) and 89% (Quad Plate). The most disagreement tended to be in the diagnosis of *Staph aureus* and *Streptococcus* spp. Depending on the specific treatment protocols used on a particular farm, misdiagnoses may or may not be important.

## Practical Aspects of Implementing an On-Farm Culture System

***Space and Equipment needed for OFC.*** The location of the farm laboratory should be carefully considered. The laboratory should be located in a clean, well lit area that has a stable room temperature. **Farm laboratories should not be adjacent to food preparation or food storage areas** for farm workers because inadvertent exposure to bacterial pathogens can endanger human health. Sufficient space on a clean countertop should be available and refrigerator and freezer space to store supplies and samples should be readily accessible.

There are relatively few fixed costs associated with development of a farm mastitis laboratory. The most important item is the incubator and there are a variety of options available with prices running from about \$50 to \$350 dollars. Producers should not skimp on this item. It may be tempting to purchase a cheap Styrofoam egg incubator but those incubators are unlikely to be able to maintain a stable temperature & humidity, especially if they are located in a room that receives direct sunlight or has temperature fluctuations. Disposable supplies needed for OFC will vary depending on the type of media used but typically include: sterile sampling vials, nitrile or latex gloves (should be worn by all personnel that handle the plates), inoculation swabs or loops (to place milk on the media), alcohol wipes (to clean off countertops), culture plates with the selective media (available from various suppliers), and bleach (used to destroy the bacteria that grow before disposal of the plates).

***Obtaining a useful sample.*** The use of OFC is completely dependent on collection of a sterile milk sample. Mastitis occurs when teats are exposed to pathogenic bacteria that are able to overcome teat end defenses. Mastitis is therefore almost always caused by a single type of bacteria and mastitis experts consider the recovery of >2 types of bacteria from a single milk sample to be an indication of contamination during collection (NMC, 1999). If care is not taken during sampling, Gram negative bacteria will contaminate the milk sample and result in erroneous results. The following equipment is needed to ensure that a useful sample is collected:

- Sterile, single use disposable plastic vials with tight fitting caps and at least 15 ml capacity
- Nitrile or latex gloves to reduce contamination of samples with bacteria present on the samplers' hands.
- Alcohol soaked cotton, gauze or baby wipes for adequate teat sanitation.

In most instances, milk samples should be collected after the teats have been prepared for milking but before the units are attached because the number of bacterial colonies are greater in milk samples obtained before milking (Sears et al., 1991). Cows are generally more cooperative before milking and more likely to stand still to allow collection of a clean sample and there is less parlor pressure to release the cows. Before obtaining the sample, the udders should be clean and dry and a strip cup should be used to collect 3 streams of foremilk from each quarter. Teats should be sanitized using an approved teat disinfectant (such as 0.5% iodine) that remains on the tests for *20 to 30 seconds* prior to removal. The procedure for collecting the sample is as follows:

- *Thoroughly dry the teat* with a single use cloth or paper towel. Scrubbing of the teat end should be vigorous to fully sanitize the teat using 70% ethyl or isopropyl alcohol. If multiple

teats are sampled a separate swab must be used for each sample. Sanitation is not complete until the surface of the swab remains clean after it is used.

- The cap should be removed from the sample vial without touching the inside and it should be held so that the inner surface faces down. Milk from the teat to be sampled can be directed at an angle into the sampling vial. A sample size of 3-5 ml is usually adequate. The cap should be immediately replaced after the sample is obtained.

Milk is an excellent growth media and if not handled properly small numbers of non-mastitis bacteria may grow and result in erroneous results. Milk samples need to be cooled immediately and should not be placed on warm surfaces (such as the top of milk lines) for any significant amount of time. If samples are to be submitted to a actual diagnostic laboratory, they should be submitted within 24 hours of collection. If samples cannot be processed within 24 hours, they should be frozen until transported to the lab. Freezing for periods of <2 weeks has minimal effects on recovery of most mastitis causing bacteria but can reduce recovery of Mycoplasma.

**Evaluating results.** The presence of a key person to consistently read plates and evaluate results is an important determinant of success. Negative results (no growth of bacteria from milk samples) are a common outcome and typically account for about 30% of milk samples obtained from cases of clinical mastitis (Table 3). Gram negative pathogens are commonly recovered from about 25% of clinical cases. In many instances the “no treatment” decision will be made for these two categories of results (about 50-60% of samples on many farms).

Table 3. Prevalence of recovery of pathogens from cases of severity score 1 & 2 clinical mastitis

	Number of herds	Number Cases	Pathogens					
			S aureus	CNS	Strep spp.	Coliform	Other	No Growth
Hoe & Ruegg, 2005	4	217	1%	13%	24%	25%	8%	29%
Pantoja & Ruegg, 2009	1	68	1%	11%	26%	29%	9%	24%
Oliveira & Ruegg, (unpub)	8	229	21% <sup>a</sup>	6%	16%	28%	2%	27%

<sup>a</sup>Herds for this study were selected based on history of Staph aureus mastitis

**Economic Impact of Using On-Farm Culture.** We initially evaluated the use of a culture based treatment protocol in a 600 cow dairy herd that was experiencing a herd problem with clinical mastitis, excessive use of antibiotics and extended days of milk discard. Mastitis cases were identified by milking technicians and diverted into a treatment pen for examination by senior farm personnel. For each clinical case, the farm personnel collected duplicate milk samples and froze one sample for laboratory analysis. The second milk sample was used to inoculate 3 separate Petrifilm™ media (aerobic, coliform, and Staph Express). Petrifilm™ plates were read on the farm and treatments were applied following a protocol adapted from Hess et al., (2003).

The treatment protocol and on-farm culturing using Petrifilm™ was implemented during May-July, 2003. Results of clinical mastitis cases (n = 267) that occurred during this period were compared to results of randomly selected clinical mastitis cases (n = 100) that occurred in February – April 2003.

Microbiological results of farm based culturing using Petrifilm™ were compared to laboratory results of the duplicate milk samples processed using standard microbiological methods. Training the farmer to correctly interpret the results of Petrifilm™ was essential for correct diagnosis of *Staph. aureus*. Initial reading of Petrifilm™ Staph Express plates by farm personnel resulted in a low sensitivity (56%) and specificity (78%), which was corrected by further training of the farmer. In spite of the reduced test characteristics, the use of Petrifilm™ in a treatment protocol was effective in improving outcomes of mastitis treatments on this dairy (Table 3). Before implementation of the treatment protocol, the dairy used an excessive number of intramammary treatments without regard to pathogen. The use of on-farm culturing using Petrifilm™ products was an effective tool to motivate the farmer to adopt a rational treatment protocol.

Table 3. Comparison of results on-farm culturing & use of a treatment protocol to pretrial period

Outcome	Without Protocol (n = 100 cases)	With Protocol (n = 267 cases)	P Value
Days out of Tank	19.7	7.8	<0.001
Number Tubes per Case	33.3	5.3 <sup>a</sup>	<0.001
Cases Receiving Intramammary Tubes (%)	87%	33%	<0.001
Cost of Tubes & Milk Discard (per case)	\$264.00	\$90.00	

<sup>a</sup>Part of the reduction was attributable to a change in intramammary tube to a once per day product

More intensive and systematic evaluations of the impact of OFC on outcomes of clinical mastitis have been performed (Lago et al., 2009a, Lago et al., 2009b, Pol et al., 2009, Wagner et al, 2007) but to date most results have only been published in abstract form. An extensive evaluation of OFC accuracy and impact on treatment outcomes has been underway in a multistate clinical trial (Lago et al., 2009, a & b). This study evaluated both short term (risk to receive secondary therapy & total days of milk discard) and longer term (recurrence, SCC, milk yield and culling/death) outcomes. Cases of grade 1 & 2 clinical mastitis were assigned to receive either immediate intramammary treatment (n = 220) with cephapirin sodium (CefaLak) or treatment protocols determined after a 24 hour delay, based on results of OFC (n = 210). After reading the results of the OFC, cases assigned to the OFC group that were either caused by Gram negative pathogens or were culture negative did not receive intramammary antibiotics whereas cases caused by Gram positive pathogens received intramammary treatment with cephapirin sodium. A greater proportion of cases that were treated immediately required secondary treatment (36% immediate versus 19% culture based) and those cases had a tendency to require longer milk discard (5.9 days versus 5.2 days) as compared to cases that were enrolled in the culture based protocol. Cases assigned to the OFC group, did not differ with respect to recurrence, (35% versus 43% for immediate versus culture based, respectively), somatic cell score at the next test (4.2 versus 4.4 for immediate versus culture based, respectively), daily milk yield (66 lbs versus 68 lbs for immediate versus culture based, respectively) or culling and death (28% versus 32% for immediate versus culture based, respectively).

The cost effectiveness of OFC was evaluated in a study that enrolled 189 cases of mild to moderate mastitis (Pol et al., 2009). After accounting for all costs, treatment of only Gram positive infections resulted in a net income of about \$3,342 per month or about \$18 per case.

## Conclusion

The appropriate treatment for mild and moderate cases of clinical mastitis will vary depending on the pathogen and the only way to differentiate among pathogens is to culture milk samples. A number of farms are successfully using OFC systems and 80% of the time, the diagnosis made on the farm is sufficiently accurate to help guide mastitis therapy. The 24 delay in initiating treatment does not seem to adversely affect treatment outcomes and reduced antibiotic usage can improve the cost effectiveness of treatment.

## References

- Erskine, R. J., S. A. Wagner, and F.J. DeGraves. 2003. Mastitis therapy and pharmacology. in *Veterinary Clinics of North America. Food Animal Practice.* 19(1):109-138.
- Godden, S. A. Lago, R. Bey, K. Leslie, P. Ruegg, and R. Dingwell. 2007. Use of on-farm culture systems in mastitis control programs. *Proc.NMC Regional meeting, Visalia CA, May 22-23, 2007.*
- Hess, J., L. NEuder, and P. Sears. 2003. Rethinking clinical mastitis therapy. In *Proceedings of the 42<sup>nd</sup> Annual Meeting National Mastitis Council.* Jan 26-29, Fort Worth TX, pp 372-373.
- Hoe, F.G.H., and P. L. Ruegg. 2005. Relationship between antimicrobial susceptibility of clinical mastitis pathogens and treatment outcomes. *J Am. Vet. Med. Assoc.* 227:1461-1468.
- Lago, A., K. Leslie, R. Dingwell, P. Ruegg. L. Timms., and S. Godden. 2006. Preliminary validation of an on-farm culture system. *Proc. NMC,* pp 290-291.
- Neeser, N. L., W. D. Hueston, S. M. Godden, and R. F. Bey. 2006. Evaluation of the use of an on-farm system for bacteriologic culture of milk from cows with low-grade mastitis. *J Am Vet Med. Assoc.* 228:254-260.
- National Mastitis Council. 1999. *Laboratory handbook on bovine mastitis.* 1999. NMC, Madison WI.
- Owens, W. E., C. H. Ray, J. L. Watts and R. J. Yancey. 1997. Comparison of success of antibiotic therapy during lactation and results of antimicrobial susceptibility test for bovine mastitis. *J Dairy Sci.* 80:313-317.
- Pol, M. and P. L. Ruegg, 2006. Relationship between reported antimicrobial usage and phenotypic antimicrobial susceptibility of mastitis pathogens. In *Proceedings of the 45th Annual Meeting National Mastitis Council.* Jan 22-25, Orlando, FL, pp 304-305.
- Pol, M, Bearzi, C., Maito, J., and Chaves, J. 2009. On-Farm Culture: Characteristics Of The Test. *Proc. 48<sup>th</sup> Ann., Meeting NMC., Charlotte, NC, Jan, 25-28, 2009.*
- Pyörälä, S.H. and E. O. Pyörälä. 1998. Efficacy of parenteral administration of three antimicrobial agents in treatment of clinical mastitis in lactating cows: 487 cases (1989-1995). *J Am Vet Med Assoc.* 2121:407-412.

Rodrigues, A.C.O., D. Z. Caraviello, and P. L. Ruegg. 2005. Management of Wisconsin Dairy herds enrolled in Milk Quality Teams. *J Dairy Sci.* 88:2660-2651.

Rodrigues, A.C. O., Roma, C. L., T. G. R., Amaral, and P. F. Machado. On-farm Culture and Guided Treatment Protocol. Proc. 48<sup>th</sup> Ann., Meeting NMC., Charlotte, NC, Jan, 25-28, 2009.

Ruegg, P.L., 2004. Estratégias de tratamentos da mastite clínica in proceedings VIII Curso Novos Enfoques Na Produção e reprodução de bovinos. Uberlandia, March 18-21.

Sol, J., O. C. Sampimon and J. J. Snoep and Y. H. Schukken. 1997. Factors associated with bacteriological cure during lactation after therapy for subclinical mastitis caused by *Staphylococcus aureus*. *J Dairy Sci* 80:2803-2808.

Wenz, J. R., G. M. Barrington, F. B., Garry, et al., 2001. Bacteremia associated with naturally occurring acute coliform mastitis in dairy cows. *J Am Vet Med Assoc* 219:976-981.

Wenz, J. R., G. M. Barrington, F. B., Garry, R. P. Dinsmore, R. J. Callan. 2001. Use of systemic disease signs to assess disease severity in dairy cows with acute coliform mastitis. *J Am Vet Med Assoc* 218:567-572.

Website resources: A complete guideline, protocol for on-farm milk culturing with color photos and sources of supplies can be found in the “Major Mastitis Pathogen Isolation and Treatment Guideline” (brochure) or at [www.cvm.msu.edu/~sears/isolation.htm](http://www.cvm.msu.edu/~sears/isolation.htm) .

<http://qmps.vet.cornell.edu/Services/minnesotaculturemanual.pdf>



# Managing Feed and Milk Price Risk: Futures Markets and Insurance Alternatives

Dillon M. Feuz  
Department of Applied Economics  
Utah State University  
3530 Old Main Hill  
Logan, UT 84322-3530  
435-797-2296  
[dillon.feuz@usu.edu](mailto:dillon.feuz@usu.edu)

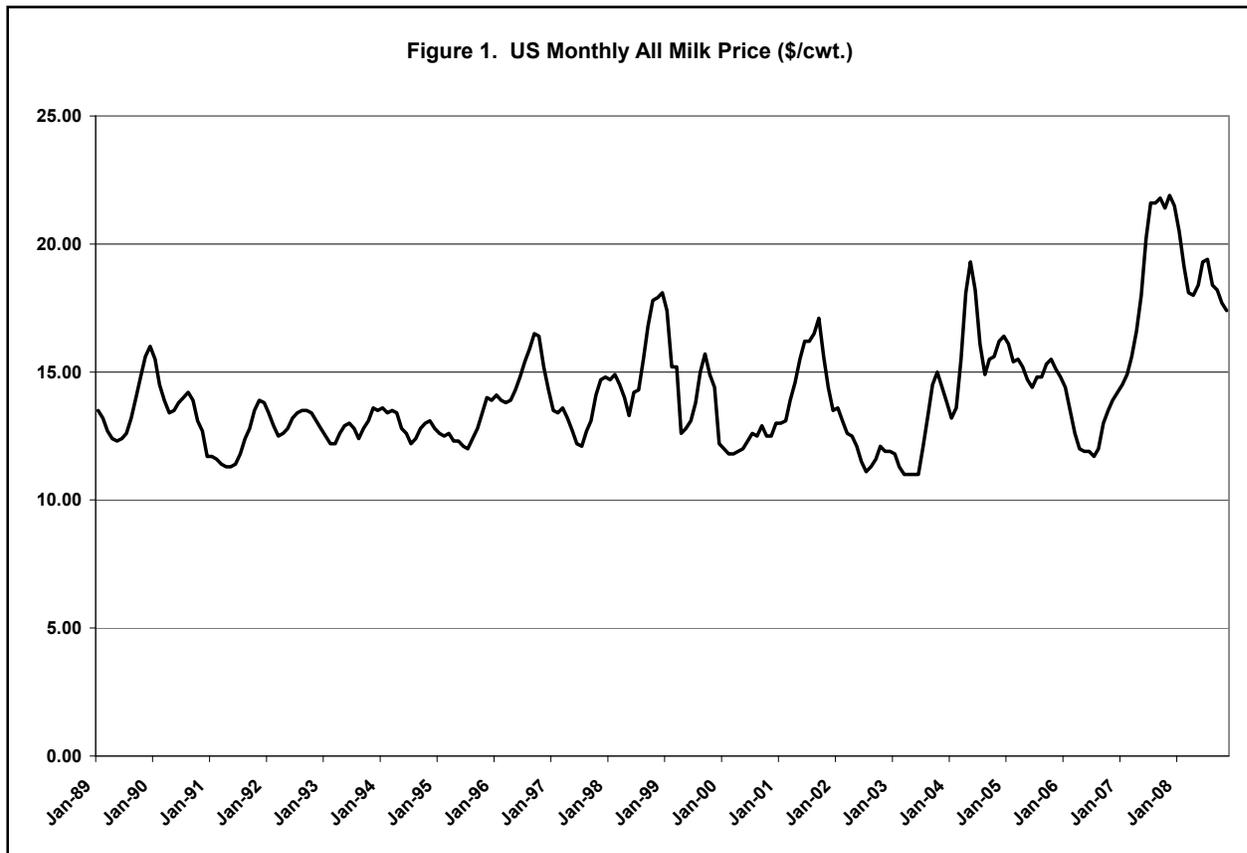
## Executive Summary

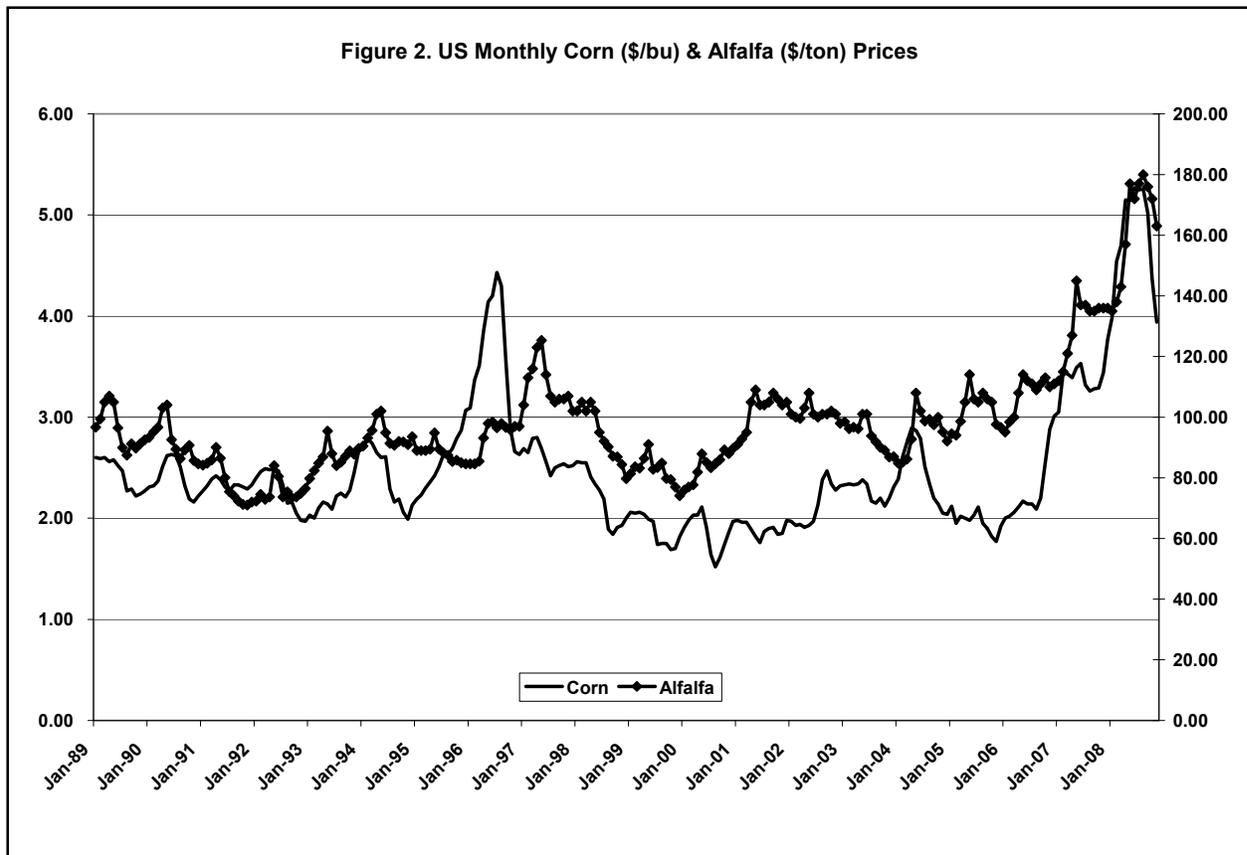
- Milk and feed prices have become more volatile in the past few years
- Increased exports of milk products has contributed to increased volatility and will likely continue into the future
- US government mandates on ethanol use has tied the grain markets closely to the energy markets. This has increased the price of grains and the volatility of prices. This will continue into the future
- Dairy producers' returns are now more volatile and will continue to be volatile
- There are tools producers can use to manage volatility
  - Futures Markets
  - Options Markets
  - Crop Insurance (Livestock Gross Margin-Dairy)
- Futures can be used to lock in milk price and corn price
  - Minimizes price risk
  - Can't benefit from higher milk prices or lower feed prices
- Options can be used to set a minimum milk price and a maximum corn price
  - Can choose the level of price protection
  - Option premium is the cost for this price protection
- LGM-Dairy insures the margin between milk revenue and feed costs (corn and soybean meal)
  - Not available in all states
  - Similar to buying options in the market place
  - Cost of insurance is similar to cost of option premiums
  - More flexible in terms of quantity of milk and feed insured
- No one method is "best" in all times and situations
  - Varies over time
  - Varies across operations
  - Varies based on your tolerance for risk

## Introduction

In the last several years many commodity markets have become more volatile. The dairy industry and milk prices have followed this trend. Monthly historical milk prices for the last 20 years are displayed in Figure 1. With only a few exceptions, monthly prices generally varied between about \$11.50 and \$13.50 per cwt. from 1989 to 1998. However, since that time prices have been more volatile with several instances of prices over \$15 per cwt, and even a few months with prices over \$20 per cwt. If there is a positive to this increased variability, it is that most of it has been in the form of higher prices and not lower prices.

Feed costs account for about half of the total cost of producing milk. Feed prices have also seen an increase in the volatility and particularly in the last few years feed prices have increased substantially. Monthly historical corn prices and alfalfa prices for the last 20 years are displayed in Figure 2. Changes in variability are less apparent over time from looking at the plots in Figure 2, but clearly the increased price level is apparent since 2006. There are several factors that have contributed to these higher prices and increased variability; one major factor is the coupling of corn prices with oil prices through the US energy policy and mandated increases in ethanol use. This new mandated demand for corn as increased all crop prices as there is a limited number of crop acres and as many crops are prices to some degree based on the energy equivalent to corn.





Prices for corn and therefore many other crops will likely also remain more volatile in the future as the price of corn is now heavily influenced by the price of oil. Now there are not only traditional agricultural issues that influence crop prices, but all of the issues surrounding oil supply and demand also influence crop prices. As the US dairy industry has increased export sales, this has led to an increase in demand for milk. However, increased exports also contribute to increased volatility in milk prices. Exports are influenced by market factors in the importing countries, market factors from competing export nations, and the strength or weakness of the US dollar.

What has happened to dairy producers returns in this market environment of increased volatility in both milk prices and feed prices? What tools are available to producers to manage this increased risk? The answers to these questions are the objectives of this paper.

The next two sections of this paper will discuss the tools available to producers to manage market risk. The first section will discuss the futures and options markets and discuss the advantages and disadvantages of these tools in managing milk price and corn price risk. The second section will introduce a relatively new insurance product that is available to dairy producers in some states to insure a margin between milk revenue and feed costs. The insurance is known as Livestock Gross Margin-Dairy (LGM-Dairy).

Milk, corn and alfalfa prices will be analyzed to quantify the level of prices and the variability of prices in different time periods and this information will be used to simulate net returns to dairies

over three different time periods. Simulated returns from remaining in the cash market, using futures, and using options to managing risk will be determined for three different time periods. The expected return from using LGM-Dairy will be discussed.

### **Futures and Options**

Futures contracts are standardized, legally binding agreements to buy or sell a specific commodity, such as corn or milk, in the future. The buyer and seller of a futures contract agree on a price today for a specific quantity and quality of a commodity to be delivered at a specific time and location. The specifications of the futures contracts, quantity, quality, delivery time and location are all predetermined by the futures exchanges that trade those commodities. However, many individuals wanting to either buy the commodity or sell the commodity determine the price in a competitive market environment.

There are many individuals that buy and sell futures contracts that never own or intend to own the actual commodity. However, some individuals do own the commodity or do intend to purchase the commodity in the future. These individuals can force others to either take delivery from them, or to make a delivery to them for the specified quantity and quality of a commodity. This action, or threat of action, is one mechanism that ensures that the underlying cash market and the futures market for the same commodity tend to respond in like manner to new supply and demand information.

Buying or selling futures is similar to entering into forward contracts to buy or sell a commodity. The main difference being that with a forward contract delivery almost always occurs and with futures generally rather than delivery occurring each party to the contract gets out of the contract by taking the opposite position in the market. For example, suppose a dairy contracted in May with a farmer to buy 5,000 bushels of corn in November for \$4.00 per bushel. Normally, in November the dairy would receive the 5,000 bushel and pay the \$4.00 per bushel. If cash prices had declined to \$3.50 per bushel then the dairy would be worse off for contracting. However, if the cash price in November was \$4.50 per bushel, then the dairy would be better off for contracting. Likewise the dairy could buy a December corn futures contract in May, which is for 5,000 bushel. If in November the dairy buys 5,000 bushel of corn from the neighbor for \$3.50 per bushel, he then must sell the December corn futures at \$3.50 (assuming zero basis). Because he bought December corn futures for \$4.00 and sold them for \$3.50 he loses \$0.50 per bushel, so that effectively means his corn cost him \$4.00 (\$3.50 cash + \$0.50 futures loss). However, if the cash price in November is \$4.50 and he buys the corn, he then sells the December corn futures for \$4.50 and earns \$0.50 per bushel in the futures market. Therefore the effective price he paid for corn is \$4.00 (\$4.50 cash - \$0.50 futures gain). Therefore, with either a cash forward contract or the purchase of corn futures the price of corn ended up at \$4.00 per bushel regardless of whether the market moved higher or lower.

The advantages of using futures as compared to a cash forward contract are that you can buy or sell them anytime the market is open; you can buy and sell contracts for more than a year in advance and there are no direct negotiations with the other party. The disadvantages are that you must put up a performance bond, margin money, in a futures trading account and maintain a minimum balance in this account; and the cash price and the futures price are not always equal nor are the differences always predictable. This creates what is known as basis risk.

By definition:  $\text{Basis} = \text{Local Cash Price} - \text{Futures Price}$ .

A dairy producer can lock-in a fixed selling price for milk by executing a short hedge (the net realized price will vary somewhat due to basis). The expected hedge price is the futures price plus or minus the expected local basis. In the case of milk, dairy producers would use their mail box price as the local price and they would use the class III milk futures for the futures market. This strategy is executed by selling the futures contract for the month that the cash sale is expected to occur. The hedge is lifted at the time the milk is sold in the cash market by buying back the futures contract at that time. For example, in August 2008, the December Class III Milk futures price was \$17 per cwt. If your mail box price of milk in December is normally \$1 above the Class III Milk futures, then a producer who sold a December Class III milk futures contract for \$17, would have expected to receive a net price for milk of \$18 in December. In December 2008, this contract was trading for \$15 per cwt. If your mail box price in December was \$16, then your basis was as expected, and your net price for milk would have been \$18 per cwt. (\$16 mail box price + \$2 gain in futures from selling at \$17 in August and buying for \$15 in December).

A dairy producer could lock-in a fixed purchase price for feed grains, corn in this example, by executing a long hedge (the net realized price will vary somewhat due to basis). The expected hedge price is the futures price plus or minus the expected local basis. This strategy is executed by buying the futures contract for the month that the cash purchase is expected to occur. The hedge is lifted at the time the corn is purchased in the cash market by selling the futures contract at that time. For example, in December 2008 the May Corn futures were trading at \$4.00 per bushel. If your local cash price in May is typically \$0.25 higher than the May futures, then your expected net purchase price would be \$4.25 per bushel. To hedge the corn, you would sell May futures in December and then buy back May futures in May when you actually buy the corn. If the market increases between now and May you will pay more for cash corn but realize a gain in the futures. If the market is lower in May you will gain in the cash market but have a loss in the futures.

Using the futures market does reduce price risk. However, not only will selling milk futures or buying corn futures protect you from lower milk prices or higher corn prices, the futures market also prevents you from enjoying higher milk prices or lower corn prices. What producers are typically more interested in is a tool that will protect them from lower milk prices but still permit them to benefit from higher prices, and to protect them from higher corn prices but still allow them to benefit from lower corn prices. There is such a tool, but there is a cost to get this type of insurance.

An option is a legally binding contract that contains a right, but not an obligation to either buy (call option) or sell (put option) an underlying futures contract. Producers choose the specific price (strike price) that they want to insure, and the cost (premium) is negotiated in the market place. One of the primary differences between futures and options is that a futures contract is an obligation to either buy or sell the underlying commodity whereas an option provides the right but not the obligation to either buy or sell the underlying commodity futures contract. With a futures contract, both the buyer and seller have market obligations to fulfill.

Dairy producers can establish a minimum or "floor" price for milk by buying a Put Option on the Class III Milk futures. The floor price that the Put offers is the Strike price of the option minus the premium costs plus or minus the expected basis. (The floor price will vary somewhat due to basis).

This strategy is executed by buying a Put option. A higher strike price, more insurance, will result in a larger premium cost and the longer the time until the option expires will also result in higher premiums. If the underlying market increases the most a producer can lose is the premium. So, purchasing a higher strike put at a higher premium will result in a lower net selling price if the market increases compared to purchasing a lower strike put at a lower cost. However, if the market declines, the higher strike put will result in a higher floor price. A producer must weigh the premium costs against the level of price insurance to determine what option strike price to purchase.

When the milk is sold in the cash market, you usually would sell the put option if it had any value. If milk prices have increased above the strike price it is likely that the option will have no value and you simply let it expire. However, if prices have declined below the strike price, then it will have value. Selling this put for that value is why you have purchased the price insurance. This is what establishes a minimum price.

There are several advantages of buying a put option over selling a futures contract: you establish a minimum price but you can still take advantage of higher prices; there is no performance bond required, no margin calls; and you can choose the level of price insurance (strike price) that is best for you. However, you must pay the premium cost and purchasing price insurance a long time in advance of sale can be expensive.

Dairy producers can establish a maximum or "ceiling" price to be paid for corn by buying a Call Option. The ceiling price that the Call offers is the Strike price of the option plus the premium costs plus or minus the expected basis. (The ceiling price will vary somewhat due to basis).

This strategy is executed by buying a Call option. A lower strike price, more insurance, will result in a larger premium cost and the longer the time until the option expires will also result in higher premiums. If the underlying market decreases the most a producer can lose is the premium. So, purchasing a lower strike call at a higher premium will result in a lower net selling price if the market decreases compared to purchasing a higher strike call at a lower cost. However, if the market increases, the lower strike call will result in a lower ceiling price. A producer must weigh the premium costs against the level of price insurance to determine what option strike price to purchase.

When the corn is purchased in the cash market, you usually would sell the call option if it had any value. If corn prices have decreased below the strike price it is likely that the option will have no value and you simply let it expire. However, if prices have increased above the strike price, then it will have value. Selling this call for that value is why you have purchased the price insurance. The advantages of buying the call option over buying the futures market are: you establish a maximum price but you can still take advantage of lower prices; there are no margin calls; and you can choose the level of price insurance (strike price) that is best for you. Once again you must pay the premium cost to obtain this protection and purchasing price insurance a long time in advance of grain purchases can be expensive. Also, it is important to note that most grain options expire about 30 days prior to the futures contract expiration.

An example of a call option, in December 2008 the May Corn futures were trading at \$4.00 per bushel and you could purchase a \$4.10 strike for \$0.40 per bushel. If your local cash price in May is typically \$0.25 higher than the May futures, than your expected maximum purchase price would be \$4.75 per bushel ( $\$4.10 \text{ strike} + \$0.40 \text{ premium} + \$0.25 \text{ basis}$ ). If the market increases between now

and May to \$6.25 for your cash price and May corn Futures are at \$6.00 you will pay more for cash corn but realize a gain in the options market. You could sell the \$4.10 call option for \$1.90 per bushel (\$6.00 - \$4.10). Your net purchase price for the corn would then be \$4.75 per bushel (\$6.25 cash price + \$0.40 premium to purchase option - \$1.90 premium to sell option). If the cash market is at \$3.00 in May you will gain in the cash market and you will forfeit your \$0.40 call premium. Your net price for the corn would be \$3.40 per bushel.

More information on trading dairy futures and options can be obtained at:

[http://www.cme.com/files/Primer\\_for\\_Traders2.pdf](http://www.cme.com/files/Primer_for_Traders2.pdf)

Additional information on trading corn futures and options can be accessed at the following link:

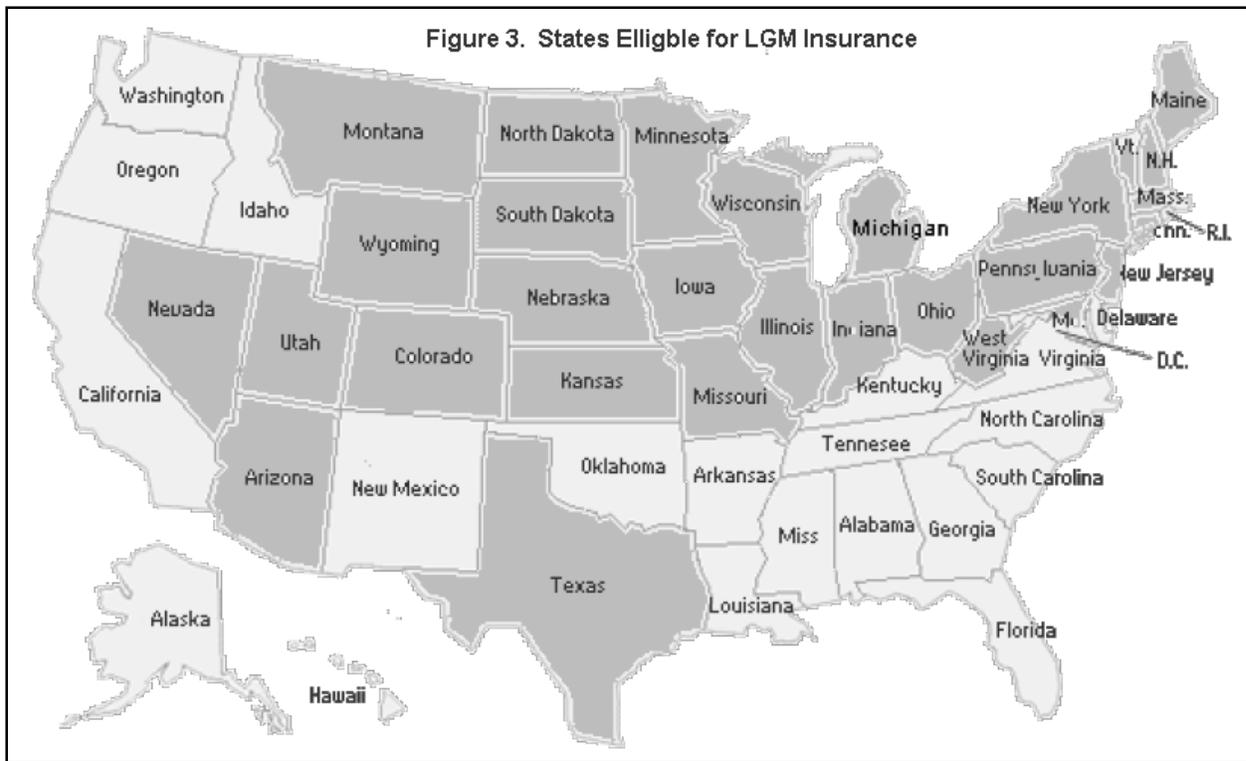
<http://www.cbot.com/cbot/docs/76474.pdf>

### **Insurance**

The United States Department of Agriculture-Risk Management Agency (RMA) has recently released a new insurance product for the dairy industry starting with the 2009 insurance year. It is known as Livestock Gross Margin-Dairy (LGM). It is designed to insure the margin between feed costs and milk revenue. "LGM Dairy protects against loss of gross margin (market value of milk minus feed costs) on milk produced from dairy cows. The indemnity at the end of the 11-month insurance period is the difference between the gross margin guarantee and the actual gross margin (if positive). The policy uses futures prices and state basis for corn and milk to determine expected and actual gross margin, and may be tailored to any size farming operation. LGM Dairy is different from traditional options in that it is a bundled option covering the price of both milk and feed costs. Producers can sign up 12 times per year and insure up to 240,000 cwt per year."

<http://www.rma.usda.gov/news/2008/05/lgmdairy.html>

While the product claims to insure the margin between milk revenue and feed costs, it really only insures the margin between milk revenue and corn and soybean meal or their equivalents. Hay and pasture costs are not part of the insurance. The product is also not available in all states. The states eligible to participate in LGM-Dairy are displayed in Figure 3. Three major dairy states in the west, California, Idaho and New Mexico are not eligible. However, it may be the case that those states will become eligible in future years.



In theory, the LGM-Dairy insurance is similar to purchasing a put option on milk futures and purchasing call options for corn futures and soybean meal futures. An advantage of the insurance over using the options market is the insurance contract can be tailored to any size of dairy, whereas the options on futures are for fixed quantities of milk, corn and soybean meal. For greater detail on this insurance product the reader is encouraged to read a paper from the University of Wisconsin that can be accessed at the following web location:

[http://future.aae.wisc.edu/lgm-dairy/m&P\\_lgm\\_dairy\\_final\\_v2.pdf](http://future.aae.wisc.edu/lgm-dairy/m&P_lgm_dairy_final_v2.pdf)

### **Simulated Risk – No Risk Management Tools Used**

The data displayed in Figures 1 and 2 were divided into three time periods: 1989-1998, 1999-2008, and 2006-2008. The average price was calculated for each time period as well as the standard deviations and the coefficient of variation, which is a relative measure of variability. Those statistics are displayed in Table 1.

Milk prices have obviously become more variable. The standard deviation has increased and the coefficient of variation as more than doubled from the earlier time period to the most recent time period. Alfalfa prices have risen considerably and have also become much more variable. Both milk prices and alfalfa prices have relative variability now around 20% compared to around 10% in the 1989-1998 time period. Corn prices are even more variable than either milk or hay prices. The relative variability has increased from 18.52% to over 30% in the more recent time periods.

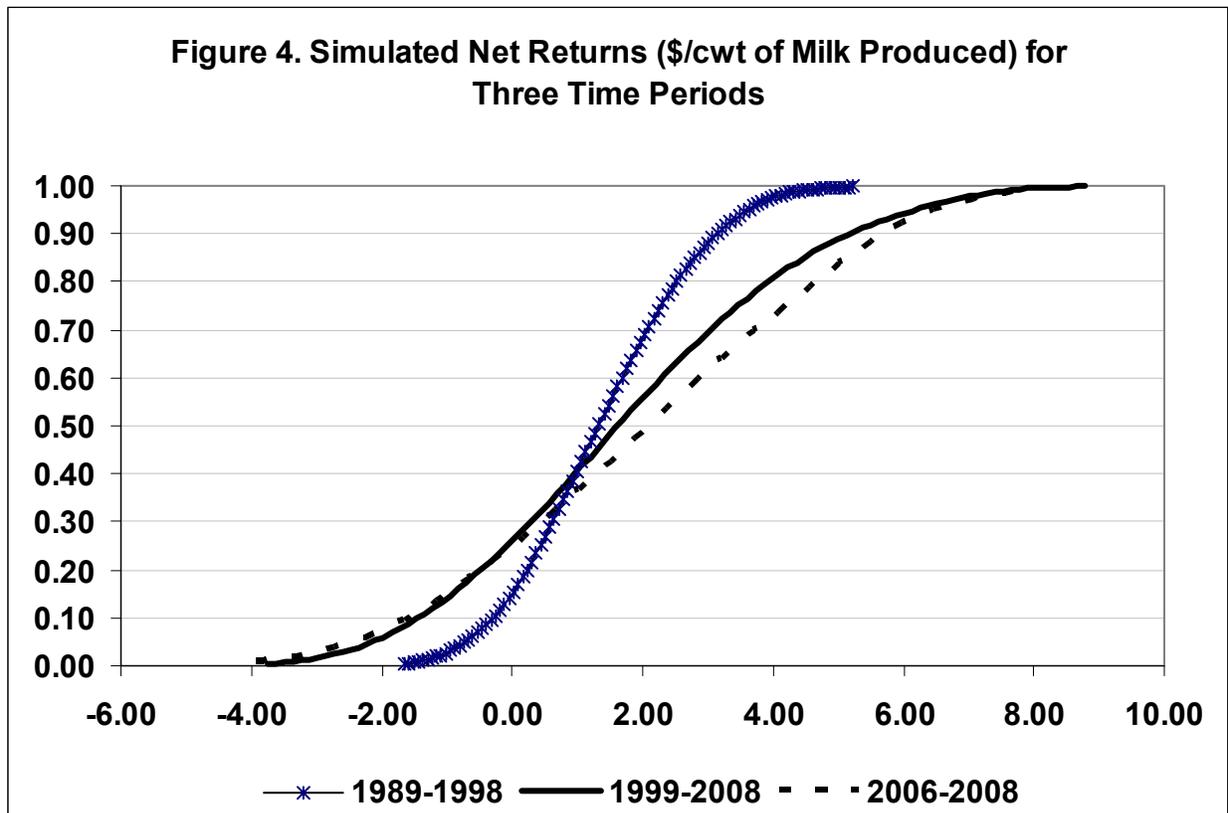
A budget typical of a 400 cow dairy was used to evaluate net returns for each of the three time periods. Milk, alfalfa and corn prices were allowed to vary based on the historical variability for

each time period. A simulation program, SIMETAR, was used to simulate net returns. There were 500 iterations run in the simulation model. The results of the simulation are displayed in Figure 4. This is a graph that shows the cumulative distribution function for each simulation.

Table 1. The Average, Standard Deviation, and Coefficient of Variation for Milk Price (\$/cwt.), Alfalfa Price (\$/ton), and Corn Price (\$/bu.)\*

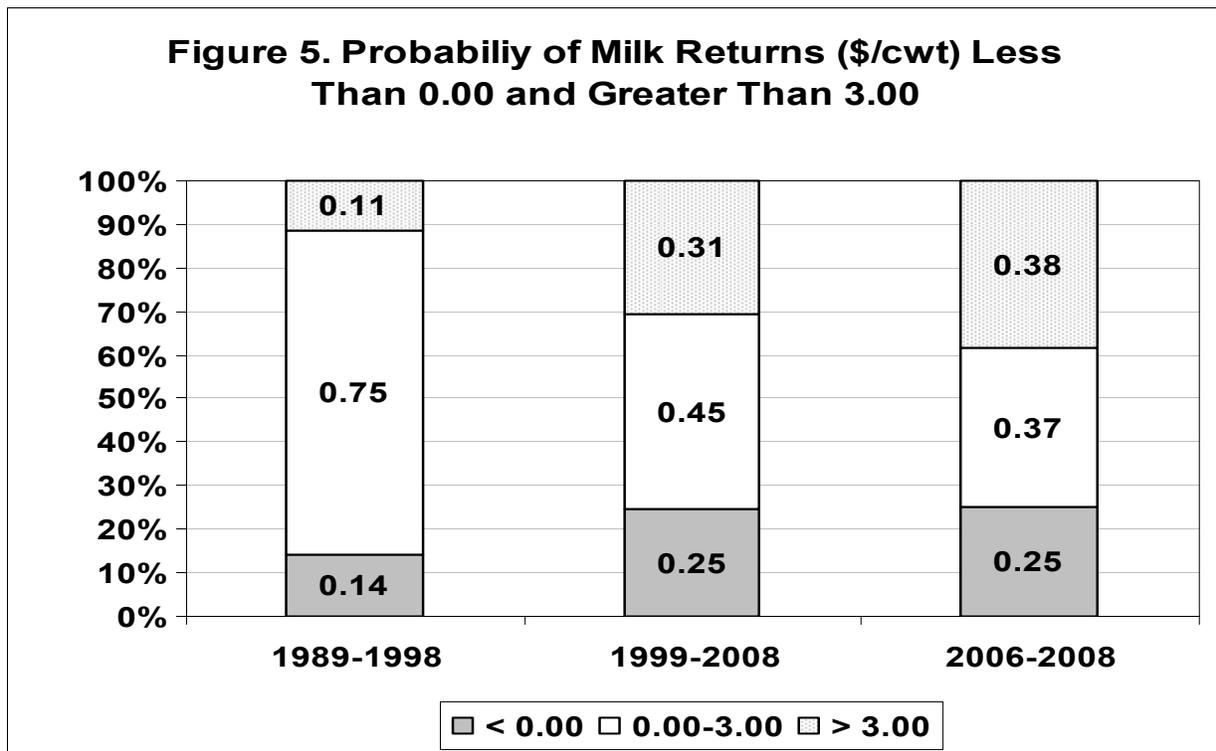
	1989-1998	1999-2008	2006-2008
Milk Price			
Average	13.48	14.77	16.82
Standard Deviation	1.33	2.78	3.44
Coeff. of Variation	9.83%	18.81%	20.44%
Alfalfa Price			
Average	91.04	105.82	132.99
Standard Deviation	10.90	23.62	25.34
Coeff. of Variation	11.97%	22.24%	19.06%
Corn Price			
Average	2.50	2.47	3.45
Standard Deviation	0.46	0.89	1.09
Coeff. of Variation	18.52%	36.04%	31.55%

\* All Prices are National Average Prices



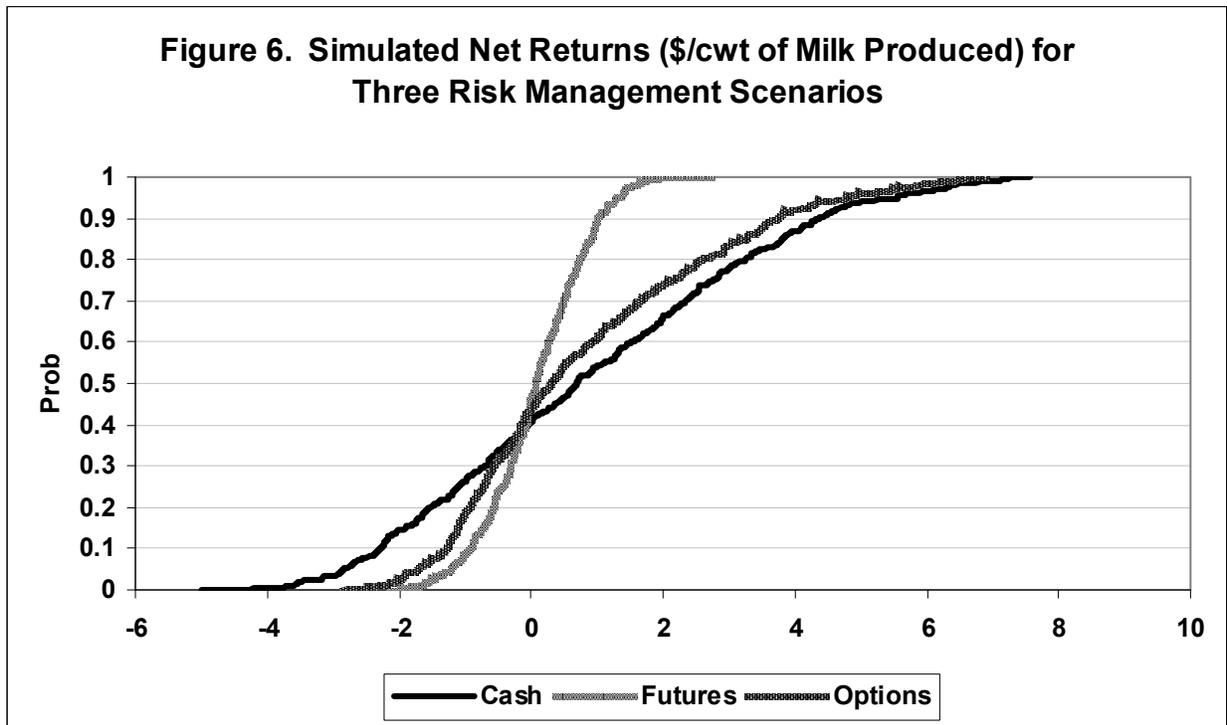
The interpretation is the line shows the probability that net returns will be less than that value. For example, there is a probability of 1, or 100% of the time, that net returns in the 1989-1998 time period will be less than \$5.23 per cwt. of milk produced and there is a .5 probability, or 50% chance, that returns will be less than 1.38 per cwt. There is also a 0 probability that returns will fall below -\$1.64 per cwt. of milk produced in the 1989-1998 time period.

The simulation also illustrates that on average dairy producers are earning greater returns per cwt. of milk produced in the more recent time periods compared to the early period. However, there is more risk; not only is there a higher probability of earning more than \$3 per cwt, there is also a higher probability of losing money (returns less than 0). Figure 5, illustrates these probabilities more clearly than Figure 4.



How would the use of futures or options impact these returns? Another simulation analysis was conducted based on the variability for the 2006-2008 time period and the current market prices and future market data for December 2008. One scenario for the simulation assumed that no risk protection was used. A second scenario involved the use of futures hedges. Milk price was hedged using the Class III Milk futures and basis was assumed to vary between \$0.50 and \$1.50, in other words the producer's mail box price would be \$0.50 to \$1.50 per cwt. above the Class III Milk futures. Corn price was also hedged using Corn futures. Corn basis varied between \$0.25 and \$0.75 per bushel. A third scenario involved the uses of options rather than futures. Put options for Class III Milk were purchased to establish a minimum price for milk and call options for Corn were purchased to establish a maximum price for feed. Alfalfa hay prices varied in the simulation based on the recent variability and there was no risk protection used with regards to alfalfa price. The

results of this simulation are displayed in Figure 6. Once again, the cumulative distribution functions for each of the scenarios are displayed for comparison.



There are a number of observations that can be made from looking at the graphs in Figure 6. Remaining in the cash market is the most risky, returns vary the greatest. However, in the case of the current market conditions, the expected return is also higher by remaining in the cash market. This will often be the case; essentially it costs you something to remove risk from your operation. Using the futures market to lock in milk and corn prices is the least risky alternative, returns vary the least. There is still hay price risk in this scenario, and also basis risk with milk and corn. It may not be obvious from the graph what is generating the higher expected returns or the lower expected returns with each scenario. The higher returns result when milk prices are higher and corn and alfalfa prices are lower, and obviously the reverse is true that the lower returns occur with low milk prices and high feed costs. Therefore, what is obvious is that when milk prices are higher and feed costs are lower your best alternative is the cash market. However, when milk prices are lower and feed costs are higher, than having milk and corn prices locked in with futures is the best alternative in terms of net return. The question always is: will milk prices move higher or lower and will feed costs move higher or lower. If you could answer that, you would know your best risk management strategy: cash or futures. However, given that you don't know what will happen as you consider the options strategy it is always a close second to the "best" strategy. You only lose your premium and still take advantage of higher milk and lower feed prices, but when milk prices decline and feed costs rise you have protection in place.

The relative position of these lines, the expected net returns, will vary based on your individual costs and production values. They will also vary with market conditions. There may be times when there is no real probability of losing money with any of the risk management scenarios. Likewise, there

may be times, such as the present, where there is a real probability of losing money, regardless of the risk management strategy employed. However, as these market conditions change, there will be little change in the relative position and slope of the three alternatives: cash will always show the greatest variability; futures will always show the least variability; cash will be preferred when markets move in your favor; futures will be preferred when markets move against you; and options will always be a second best alternative. But as can be seen, sometimes returns don't differ much between the "best" and second best alternative, but do differ substantially compared to the third or poorest alternative.

LGM-Dairy insurance was not included in the simulation. However, it would appear much the same as the options strategy. There would likely be a small advantage of LGM-Dairy over options for those dairies whose size did not match the milk futures or corn and soybean meal futures contract specifications very well. For larger dairies that exceed the limits of the LGM-Dairy policy, obviously the options would be more advantageous.

### Summary

Markets and market conditions are rarely static. They continue to changes though time as the world around them changes. It will likely be the case that the future will hold increased volatility in markets. As US milk prices become increasingly influenced by exports of dairy products, this tends to add not decrease volatility. It is also the case that this increase in exports has led to higher milk prices and exports will continue to support higher milk prices in the future. But it appears that US dairy producers still possess the ability to increase milk production quicker than domestic demand or export demand can increase. Grain prices will also likely show more volatility in the future than in the past. When prices were often at or near government support levels, there was much less volatility. However, the new demand for crops as renewable energy fuel as not only increased the price level but also increased the volatility. Corn prices are tied much more closely to oil prices than was the case prior to the increased government mandates for ethanol use.

Increased volatility in milk prices and feed prices will also lead to greater volatility in dairy producers' net returns. There may be times of very profitable milk production and there may also be times when milk production is not profitable at all. There are risk management alternatives available to producers to manage some of this increased volatility. Producers can utilize Class III Milk futures to hedge future milk sales and essentially lock in a fixed price for up to a year in advance. Likewise, producers can utilize Corn futures to lock in a fixed price for corn for over a year in advance if desired. The market also provides options on these future contracts. By buying put options on the milk futures, producers can establish a price floor, or minimum price, and yet still take advantage of market rallies. Similarly, by buying call options on corn futures, producers can establish a ceiling price, maximum price, for corn and yet still take advantage of lower corn prices if they occur.

With the 2009 insurance year, the USDA-RMA introduced a new insurance product, LGM-Dairy. This product is not available to producers in all states, but does allow producers to insure the gross margin between milk revenue and feed prices. More specifically, that margin is the difference between milk revenue and corn and soybean meal costs.

Each of these risk management tools can be used to reduce the variability of returns. The use of futures limits variability the most of these alternatives and using options or LGM-Dairy is similar in the amount of reduction in risk. Any time you use the market or insurance to manage risk, there is a cost. Over time, the expected returns to dairy producers who remain strictly in the cash market will likely exceed the returns of those who utilize some form of risk management. However, if a dairy does not have sufficient capital to withstand some of the bad years and still be in business to take advantage of the good years, then perhaps one of these risk management tools will work for them.



# HOW TO MAKE ID TECHNOLOGY WORK FOR YOU

Matt VanBaale, Ph.D., Jessica Wheelock M.S., Josh Heslink, and Casey Westphalen

Ultimilk Dairy Company

Patrick J. Gorden, DVM, DABVP

Iowa State University College of Veterinary Medicine

## Introduction

Technology is defined by Webster as “The discipline dealing with the art or science of applying scientific knowledge to practical problems”. Because of the lack of standardization, variables in facility, feed stuffs available, management philosophy, and overall leverage in terms of capital structure it is important for each individual dairy to know what works for that dairy. The ability to accurately forecast, manage risk, track and analyze data to improve the management of the dairy requires the use of technology at some level. In our business model it is a key part not only for management, but for lenders, capitol partners, and other stake holders. The tools we use are Feed Watch feed tracking software, Dairy Comp 305, Dairy Pro, Time Force, and Mas 90 accounting systems (Figure 1). All of these systems are in some way linked to Electronic Identification (EID) technology.

## Electronic ID technology

Electronic ID technology has been around in the dairy industry for more than thirty years. Early adoptions of the technology were for individual cow ID in milking parlors, sort gates and electronic feeders. These same types of tags are still available today with a few additional options such as activity monitoring. As dairies have become larger there has been greater emphasis placed on putting low cost methods in place that are highly efficient, accurate and effective at assisting producers manage reproduction, herd health, and daily milk yield.

According to the USDA National Animal Health Monitoring System (NAHMS) Dairy 2007 survey, 93% of cows and 97.4% of herds in the survey had some form of individual ID. Of the herds with individual ID, 4.1% of operations and 9% of cows utilized electronic ID as the method to ID at least some of the cows in the herds surveyed. In this survey, methods of electronic ID included transponders, Radio Frequency Identification (RFID) tags and bar codes. A lower percentage of farms (54%) with approximately 36% of the operations surveyed had herd ID on the individual cows.

The National Animal Identification System (NAIS) is a partnership between state, federal and industry partnership designed to assist producers with dealing with and controlling future disease outbreaks. Currently three states have mandatory programs in Indiana, Michigan and Wisconsin. NAIS programs use a tamper proof “840” tag that is NAIS compliant. Recently, New Mexico implemented a tuberculosis control program that utilizes “840” tags to track animals in the program. Other states, like Arizona, have approved “840” tags to be used for official ID for “Milk Ordinance”

TB testing that is done in the state on a tri-annual basis and for such identification purposes for health certificates and calf hood vaccination. Utilizing RFID technology on dairy farms does not require the use of official “840” tags. There are several manufacturers of RFID tags that are not NAIS compliant that are being utilized on dairy farms across the US.

### **Implementing RFID technology at Ultimilk Dairy Company**

Ultimilk Dairy Company is a 6000 cow dairy operation that began milking cows as startup company and dairy in March 2007. From the beginning, it was decided to implement electronic ID technology in order to help obtain a high degree of record accuracy as rapidly as possible. Re-usable ear tags purchased from Westphalia-Surge were chosen as they could be used to ID cows in the milking parlor for daily monitoring of milk weights in addition to being utilized for herd management.

As the first cows arrived, they were processed with a bangle tag in each ear with the cow’s visible ID and an RFID tag placed in the left ear. As the tags were placed in the cows, Pocket Cow Card (PCC) from Valley Ag Software was utilized to read the RFID tags and coordinate the RFID tag with the correct new visible ID number and previous visible ID number. In addition to accurately coordinating RFID and visible ID’s, it allowed for placement of the cow in the proper pen at the same time.

Cows were obtained from several farms with many different record keeping systems. Cows from farms using Dairy Comp 305 were easily integrated with Ultimilk’s system. Cows from farms using other management programs required a large amount of data entry but this was expedited by utilizing RFID readers. Now, as the dairy brings replacement animals into the herd, they are given an RFID tag at calving.

### **Utilizing RFID technology in the reproductive and herd health program**

**Reproduction:** Before any cows arrived at the dairy, it was decided to use a Presynch-Ovsynch program and all open cows were to be re-bred using the Resynch program. The reproductive program has not been changed since the dairy started up with the exception of timing for administration of the breeding GnRh and selective CIDR use (> 140 DIM and open).

The dairy’s voluntary wait period was determined to be 42 days for cows and heifers. Breeder’s tail chalk cows every day to detect heats and breed cows. Breeders are allowed to “cherry pick” cows in heat off the second prostaglandin shot. All cows that have not come in heat 14 days later are started on the Ovsynch shot program with the goal to have all cows inseminated by 68 days in milk. Currently the dairy has 99% of the cows having their first breeding by 68 DIM with 73% of those bred on standing heat thus not requiring timed insemination.

The Resynch program is initiated 32-38 days after the previous heat with all cows in that range receiving GnRH. Cows are preg checked the following week and any open cows are given prostaglandin at that time. After a pen is completed, the Pocket Cow Card tells us immediately which cows we are missing in order to minimize missed cows. Recently, we completed a vet check

across seven pens (> 2200 cows) of cows and were only missing one cow that had moved to the special needs barn that morning. Currently, 70% of our cows are pregnant by 150DIM, our calving interval is 13.6 months, and pregnancy rate is 20% and has been increasing steadily since beginning operation in 2007. Breeding shots are administered during the pregnancy check with the exception of the breeding GnRH which is administered according to a TAI-56 hour protocol.

Utilizing RFID and Pocket Cow Card on all cows that freshened on the dairy to effectively enroll them into the repro program as they reached the correct DIM is efficient and easy to implement. The challenge came from cows that were milking upon arrival at the dairy. All cows, regardless of what the records from the previous dairy indicated were given 35 days or more on the dairy before being preg checked and placing open cows into the synchronization program to be utilized on “No Heat” cows. In the meantime, the cows were tail chalked and bred accordingly.

The breeders carry a handheld computer running Pocket Cow Card with them and enter breeding data as the cows are bred eliminating data entry errors. In addition, they have all the cow’s vital information available to them should there be cows with health issues or are potential aborts. After preg checks and breedings are completed for the day, all of the day’s information is downloaded into Dairy Comp 305 in a matter of minutes via wireless connection. Data entry errors are minimized as manual entry has been eliminated. RFID technology and Pocket Cow Card has assisted us in obtaining the level of compliance necessary to have a respectable reproductive program.

***Herd health:*** Daily hospital lists are automatically compiled in DC 305, listing each animal in the hospital pen, current or past treatments, along with important information needed to access the animal’s health such as Milk, DIM, DCC, past events, etc. These lists are refreshed into the Pocket Cow Card daily and available to be referenced during the treatment of hospital animals. Each animal in the hospital pen can be scanned (using the RFID scanner) and the handheld computer will distinguish what she is currently being treated for, how long she has been on treatment, days in the hospital, and what her daily treatment should be. If the animal has finished treatment the handheld will instruct you to “evaluate and hold” the animal until withdrawal periods are met. If an animal is being held until she is eligible to be returned to the milk string or sold, the Pocket Cow Card will inform you for example she is “ready for beef.”

In DC 305 most common health problems encountered in the hospital pen have assigned treatment protocols. With each protocol there are an automatic number of days the animal is assigned to the treatment, and a milk and beef withholding date for that specific treatment. For example, if it is entered that an animal has metritis and is being treated with Polyflex, an antibiotic, DC 305 will automatically move that animal to the hospital pen, and assign her to the protocol selected assigning the appropriate milk withholding and beef withholding date from the final treatment day. When new animals are brought to the hospital pen, the Pocket Cow Card allows the retrieval of all the current and past information for the animal that may be helpful in assessing her current situation. It also allows hospital personnel to enter new treatments based on the written protocols in DC 305. In addition, the Pocket Cow Card can also be utilized in the process of culling animals as all milk and

beef withholding dates are automatically updated when a hospital treatment is applied. Therefore, on days when animals are being sent to market the information needed to make a decision as to whether an animal is eligible to be sold is immediately available. It also allows hospital personnel to view the milk withholding dates on currently treated animals so that animals can be sampled and returned to the general herd efficiently.

***Fresh Checks:*** All recently freshened animals are palpated 3, 6, and 9 days after parturition. Each day, DC 305 automatically generates a list of fresh cows and heifers needing to be checked. This list is refreshed onto the handheld at the same time the hospital list is uploaded and utilized by personnel to track an animal's progress through the transition period. The generated list contains DIM, calving ease, current milk yield, and any recent hospital events or treatments. During the fresh checks animals are scanned and the handheld will instruct personnel to "check for residue" on normal 3, 6, and 9 day checks, or will ask to "treat this cow" for fresh animals currently being treated for common transition disorders. Like new hospital treatments, the fresh check list also gives the option to add new treatments off the protocol list in DC 305, and can move animals directly to the hospital as needed, or enter treatments that can be conducted in the fresh pen.

At the conclusion of each day, the two herd health lists (hospital and fresh cow) can be posted in the handheld computer and wirelessly transferred directly to DC 305 within seconds. The use of RFID technology drastically decreases the amount of labor time required to manage health records, and minimizes the chance for errors to occur with manual entry of treatments, and milk or beef withdrawal dates therefore minimizing any occurrences of antibiotics in milk tanks or animals sent to market.

### **Other uses for RFID technology**

Having all cows identified with electronic IDs allows us to monitor individual cow's daily milk production, and with the milk meter system, parlor performance can be monitored on a daily basis, and pen location can be determined at each milking. At weekly vet checks, cows that are located in a pen not in agreement with DC 305 will be found and can either moved to her correct pen or simply have the pen changed in the hand held computer. Accurate pen inventories are essential to maximize feed efficiency and minimize feed wastage as these inventories are utilized by Feed Watch to develop load sheets for feed mixing.

Cow management activities such as drying cows off, pen moves, preg checks, timed AI and beef lists are simplified by increasing the speed at which cows can be found. The RFID scanner and Pocket Cow Card scan cows just about as fast as an individual can walk thus speeding up finding cows by at least two fold. When the hand held computers are returned to the office, we can tell whether cows were found by analyzing the scan date and time information to check on employee performance.

## Other Technology/Software

**Feed watch:** is used to track inventory, shrink, dry matter intakes, and to make diet changes. Intakes are tracked daily, feeds are purchased through a PO system (laid out very simply using calendar on outlook) and inventory is tracked weekly with monthly reconciliation that compared variances with both price and quantity fed (figure 2).

**Mas 90:** accounting software integrates our production, labor, accounting, and overall financial systems. Weekly production data is compiled and used to communicate within the management team as well as with the herd nutritionists and veterinarian (weekly reports, weeks since fresh DC 305, etc).

**Asset keeper:** is used for tracking assets and depreciation.

**Time force time clock:** is easy to use and set up and requires an employee's fingerprint to physically punch in and out and can also allow for punching in and out on-line for those employees that may work from off site on occasion. Time force runs as a hosted on-line application that eliminates manual collection of payroll information, simplifies time and attendance/tardiness process, reduces errors, time theft and subsequent over and under payments associated with payroll. Employees are paid incentives utilizing this technology for attendance and tardiness in addition to an overall department's respective performance based incentives. For example, in the parlor, we offer \$100/month to all milkers, pushers, and scrapers. The bonus is broken out \$15 for safety (this has essentially eliminated accidents), \$15 dollars for >99% attendance and tardiness as tracked by time force (we often go 90-120 days without losing or hiring in this department), and up to \$70 for milk quality bonus tied directly to our customer in terms of how we are paid.

The primary financial tools used to manage the dairy are risk management oriented, and involve hedging inputs (Figure 3) and hedging milk (Figure 4). Each of the previously mentioned software is more efficient and accurate through EID technology.

## Conclusion

Utilizing RFID technology partnered with Dairy Comp 305 and Pocket Cow Card, feed watch, and Mas 90 has allowed Ultimilk Dairy Company to establish and maintain a respectable reproductive program and perform many of the essential management activities with a minimal number of employees and increased data accuracy. We consistently implement a maximum lock time of 45 minutes from the last cow returns to the pen which would not be possible without the RFID management systems. The level priority allocated to accurately budget, manage risk, track and analyze data is dependent on management philosophy and overall capital structure of the dairy company, but regardless, EID is efficient and easily integrated into any structure.

Figure 1. Technological tools used

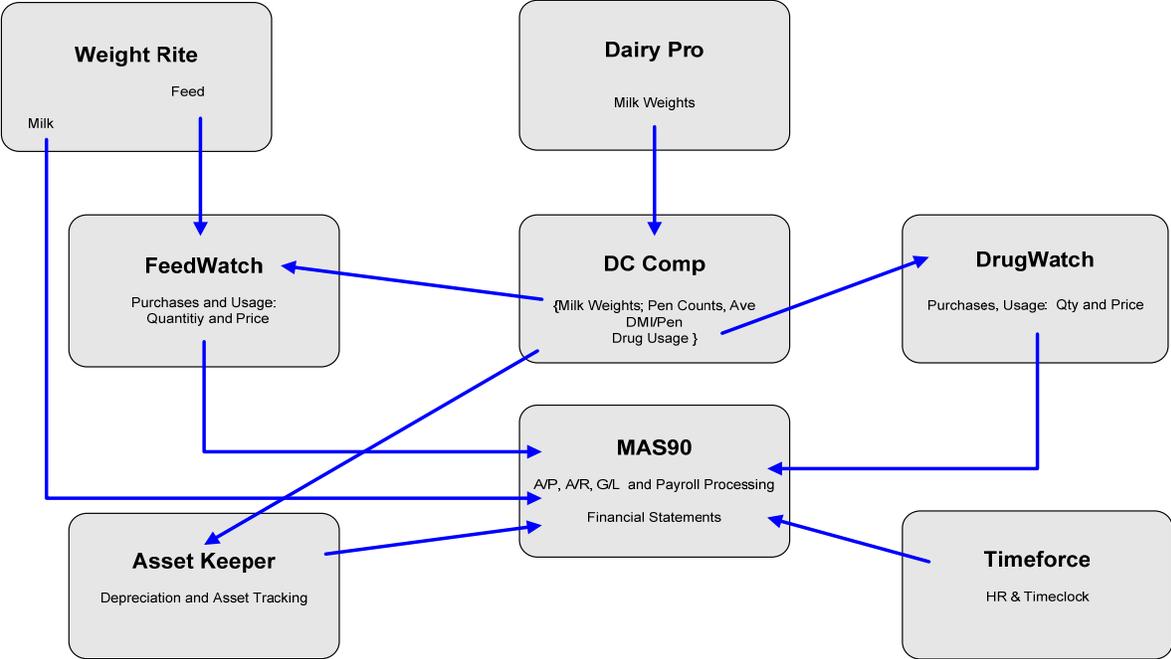


Figure 2. Monthly feed price and quantity reconciliation

Feed	Quantity			Price			Budget Variance		Pricing		Quantity	
	Budget	Actual	%	Budget	Actual	%	Actual	Variance	Budget cost	Actual Cost	Actual	Variance
Corn												
Silage	3498.7	4744.5	35.6%	\$28.00	27.99	0.0%	\$132,799	\$34,834	\$132,846	-\$47	\$97,930	\$34,869
Haylage	797.4	707.7	-11.3%	\$73.00	77.64	6.4%	\$54,943	-\$3,265	\$51,659	\$3,284	\$61,908	-\$6,965
Cottonseed	342.0	375.1	9.7%	\$385.00	374.72	-2.7%	\$140,539	\$8,861	\$144,395	-\$3,856	\$128,162	\$12,377
Corn	761.2	776.9	2.1%	\$190.71	192.48	0.9%	\$149,543	\$4,373	\$148,168	\$1,375	\$146,517	\$3,026
DDG	198.7	247.3	24.4%	\$162.11	138.58	-14.5%	\$34,263	\$2,047	\$40,082	-\$5,819	\$27,539	\$6,724
Sweet												
Bran	1245.1	1266.2	1.7%	\$73.01	73.01	0.0%	\$92,448	\$1,541	\$92,448	\$0	\$90,907	\$1,541
SoyBest	164.5	190.6	15.9%	\$306.00	387.91	26.8%	\$73,920	\$23,595	\$58,311	\$15,609	\$63,796	\$10,124
Hay	568.7	642.3	12.9%	\$212.00	220.42	4.0%	\$141,580	\$21,009	\$136,173	\$5,407	\$125,358	\$16,222
Soy Chlor	0.0	7.8		\$0.00	507.16		\$3,943	\$3,943	\$0	\$3,943	\$0	\$3,943
Straw	0.0	17.6		\$0.00	105.00		\$1,850	\$1,850	\$0	\$1,850	\$0	\$1,850
<u>Minerals</u>	132.2											
Fat	67.4	39.9	-40.9%	\$945.00	950.78	0.6%	\$37,918	-\$25,813	\$37,687	\$231	\$64,121	-\$26,203
milk cow	120.3	136.5	13.5%	\$1,100.00	729.44	-33.7%	\$99,573	-\$32,759	\$150,155	-\$50,583	\$87,754	\$11,819
fresh cow	2.6	4.2	58.4%	\$1,100.00	1,185.02	7.7%	\$4,963	\$2,054	\$4,607	\$356	\$3,133	\$1,830
Close up												
Cow	5.3	3.3	-55.3%	\$1,100.00	1,550.88	41.0%	\$3,664	-\$2,153	\$2,599	\$1,065	\$8,201	-\$5,966
Close up												
Hfr	2.6	5.7	115.8%	\$1,100.00	1,552.19	41.1%	\$8,857	\$5,949	\$6,277	\$2,580	\$4,104	\$4,753
Far off												
Dry	4.1	3.0	-27.5%	\$1,100.00	1,273.65	15.8%	\$3,821	-\$733	\$3,300	\$521	\$5,273	-\$1,452
Bred Hfrs	1.3	0.0	100.0%	\$700.00	0	100.0%	\$0	-\$925	\$0	\$0	\$0	\$0
<b>Total</b>	<b>7780.2</b>	<b>9167.6</b>	<b>17.38%</b>				<b>\$984,624</b>	<b>\$44,409</b>	<b>\$1,008,708</b>	<b>-\$24,083</b>	<b>\$914,702</b>	<b>\$68,493</b>
<b>Average</b>				<b>\$504.40</b>	<b>\$549.82</b>	<b>9.00%</b>						

Figure 3. Milk to feed margin analysis for hedging decisions

## Milk-Feed “Margin”

PRICE OPPORTUNITIES TOTAL IMPACT	<u>7/6/2008</u>	Ave thru 12/08	Average 2009
Budgeted Margin over Feed Costs		12.51	10.22
Revised Margin over Feed Costs		14.25	11.73
Milk-Feed Margin vs. Budget		1.73	1.51
<b>Milk Price vs. Budget</b>		<b>2.43</b>	<b>3.62</b>
Corn variance vs. budget		-	-
Grain Corn		(0.54)	(0.69)
Silage		-	0.19
Sweet Bran Variance		-	(0.53)
DDGS		(0.07)	(0.16)
<b>Total Corn Impact</b>		<b>(0.61)</b>	<b>(1.19)</b>
By pass SBM		-	(0.21)
Alfalfa		0.06	(0.18)
Alfalfa Haylage		-	(0.05)
WCS		(0.15)	(0.39)
By pass fat		-	(0.01)
Supplement		-	(0.06)
Vitamin/Mineral		-	(0.02)
<b>Net Feed Margin Variance</b>		<b>(0.70)</b>	<b>(2.11)</b>
Liquidity		\$ 2,212,181	\$ 5,659,199
Liquidity better (worse) than plan		\$ 882,500	\$ 2,629,271

Figure 4. Milk hedging analysis

Cash Liquidity												
Beg Cash out as of 6/30/2008 \$ 2,879,430	Potential	Total Premium (Cost) paid to date:	Net Cashout	Put % Hedged								Per .01 Change in Market
				71.43%	75.39%	75.75%	75.17%	74.18%	71.89%	71.28%		
				Call % Hedged	71.43%	75.39%	75.75%	75.17%	74.18%	71.89%	71.28%	
\$ 400,000	Total Margin Call				Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	
\$ 18.25	\$ (390,000)	\$ (390,000)	\$ (390,000)		\$ 5,744,855	\$ 4,904,012	\$ 4,195,974	\$ 3,551,002	\$ 3,516,087	\$ 4,524,866	\$ 4,859,063	\$ -
\$ 18.50	\$ (202,500)	\$ (202,500)	\$ (202,500)		\$ 5,491,730	\$ 4,650,887	\$ 4,008,474	\$ 3,363,502	\$ 3,328,587	\$ 4,337,366	\$ 4,671,563	\$ 7,500
\$ 18.75	\$ (9,000)	\$ (9,000)	\$ (9,000)		\$ 5,230,505	\$ 4,389,662	\$ 3,814,974	\$ 3,170,002	\$ 3,135,087	\$ 4,143,866	\$ 4,478,063	\$ 7,740
\$ 19.00	\$ 330,500	\$ 330,500	\$ 330,500		\$ 4,772,180	\$ 3,931,337	\$ 3,475,474	\$ 2,830,502	\$ 2,795,587	\$ 3,804,366	\$ 4,138,563	\$ 13,580
\$ 19.25	\$ 627,600	\$ 627,600	\$ 627,600		\$ 4,371,095	\$ 3,530,252	\$ 3,178,374	\$ 2,533,402	\$ 2,498,487	\$ 3,507,266	\$ 3,841,463	\$ 11,884
\$ 19.50	\$ 876,900	\$ 876,900	\$ 876,900		\$ 4,034,540	\$ 3,193,697	\$ 2,929,074	\$ 2,284,102	\$ 2,249,187	\$ 3,257,966	\$ 3,592,163	\$ 9,972
\$ 19.75	\$ 1,110,200	\$ 1,110,200	\$ 1,110,200		\$ 3,719,585	\$ 2,878,742	\$ 2,695,774	\$ 2,019,240	\$ 2,015,887	\$ 3,024,666	\$ 3,358,863	\$ 9,332
\$ 20.00	\$ 1,343,500	\$ 1,343,500	\$ 1,343,500		\$ 3,404,630	\$ 2,563,787	\$ 2,462,474	\$ 1,704,285	\$ 1,782,587	\$ 2,791,366	\$ 3,125,563	\$ 9,332
\$ 20.25	\$ 1,576,800	\$ 1,576,800	\$ 1,576,800		\$ 3,089,675	\$ 2,248,832	\$ 2,229,174	\$ 1,389,330	\$ 1,549,287	\$ 2,558,066	\$ 2,892,263	\$ 9,332
\$ 20.50	\$ 1,810,100	\$ 1,810,100	\$ 1,810,100		\$ 2,774,720	\$ 1,933,877	\$ 1,970,140	\$ 1,074,375	\$ 1,288,616	\$ 2,299,031	\$ 2,633,228	\$ 9,332
\$ 20.75	\$ 2,043,400	\$ 2,043,400	\$ 2,043,400		\$ 2,459,765	\$ 1,618,922	\$ 1,655,185	\$ 759,420	\$ 973,661	\$ 1,984,076	\$ 2,318,273	\$ 9,332
\$ 21.00	\$ 2,276,700	\$ 2,276,700	\$ 2,276,700		\$ 2,144,810	\$ 1,303,967	\$ 1,340,230	\$ 444,465	\$ 658,706	\$ 1,669,121	\$ 2,003,318	\$ 9,332
\$ 21.25	\$ 2,510,000	\$ 2,510,000	\$ 2,510,000		\$ 1,829,855	\$ 989,012	\$ 1,025,275	\$ 129,510	\$ 343,751	\$ 1,354,166	\$ 1,688,363	\$ 9,332
\$ 21.50	\$ 2,743,300	\$ 2,743,300	\$ 2,743,300		\$ 1,514,900	\$ 674,057	\$ 710,320	\$ (185,445)	\$ 28,796	\$ 1,039,211	\$ 1,373,408	\$ 9,332
\$ 21.75	\$ 2,976,600	\$ 2,976,600	\$ 2,976,600		\$ 1,199,945	\$ 359,102	\$ 395,365	\$ (500,400)	\$ (286,159)	\$ 724,256	\$ 1,058,453	\$ 9,332
\$ 22.00	\$ 3,209,900	\$ 3,209,900	\$ 3,209,900		\$ 884,990	\$ 44,147	\$ 80,410	\$ (815,355)	\$ (601,114)	\$ 409,301	\$ 743,498	\$ 9,332
\$ 22.25	\$ 3,475,200	\$ 3,475,200	\$ 3,475,200		\$ 526,835	\$ (314,008)	\$ (277,745)	\$ (1,173,510)	\$ (959,269)	\$ 51,146	\$ 385,343	\$ 10,612
\$ 22.50	\$ 4,831,500	\$ 4,831,500	\$ 4,831,500		\$ (1,304,170)	\$ (2,145,013)	\$ (2,108,750)	\$ (3,004,515)	\$ (2,790,274)	\$ (1,779,859)	\$ (1,445,662)	\$ 54,252
\$ 22.75	\$ 5,155,800	\$ 5,155,800	\$ 5,155,800		\$ (1,741,975)	\$ (2,582,818)	\$ (2,546,555)	\$ (3,442,320)	\$ (3,228,079)	\$ (2,217,664)	\$ (1,883,467)	\$ 12,972
\$ 23.00	\$ 5,480,100	\$ 5,480,100	\$ 5,480,100		\$ (2,179,780)	\$ (3,020,623)	\$ (2,984,360)	\$ (3,880,125)	\$ (3,665,884)	\$ (2,655,469)	\$ (2,321,272)	\$ 12,972



# IS A ONE TMR APPROACH RIGHT?

Michael F. Hutjens  
Extension Dairy Specialist  
University of Illinois, Urbana  
232 ASL, 1207 W. Gregory Drive  
Urbana, IL 61801  
[hutjensm@illinois.edu](mailto:hutjensm@illinois.edu)  
217-333-2928

## Take Home Messages

- Determine the optimal economic approach when deciding the optimal number of groups and number of rations.
- Multiple TMR can reduce feed cost per cow per day IF milk yield drop is less than 3 pounds per cow per day.
- Explore different ways to use the same TMR using under dressing, top dressing, and other feeding approaches.
- Monitor on an individual herd basis strategic benchmarks to decide how TMR patterns should change: milk price, feed prices, lead factors, amount of weigh back, forages available, reproductive success, and body condition score.

Feed delivery systems continue to change and evolve as herd sizes increase, by-product feeds become economically attractive, and milk and feed prices shift monthly. Hoard's Dairyman 2008 market survey of U.S. dairy managers reported 58.2 percent of surveyed herds were feeding total mixed rations. With current market changes and the loss of rBST in some milk markets, questions on using one ration mix compared to several ration approach have been raised. This paper will respond to questions and concerns raised by dairy managers, nutritionists, and veterinarians. Answers are farm specific and will depend on current feeds available, herd profile, and future milk prices.

## What is a one group TMR?

The "one ration" approach in this paper will be one ration that is mixed for all lactating cows balanced for one level of nutrients and fed to all groups or milk production strings. Guidelines for a one ration TMR are listed in Table 1. Most rations will be balanced at 80 to 90 pounds of milk allowing for higher dry matter intake to meet the nutrient needs of cows over 100 pounds of milk. Also, balancing at 80 to 90 pounds of milk results in maximum levels of fats/oils and starch with minimum levels of fiber and protein. Some managers will fine tune the use of one ration in the

following ways.

- Top dress the one group ration with a stress pack for fresh and early lactation cows.
- Under dress the one group ration by adding forages or bulky feed ingredients to dilute nutrient levels.
- Feed 25 to 33 percent of the one ration to close up dry cows to increase nutrient intake and adjust the cows to feed ingredients in the lactating ration.
- Feed the one group ration to calves from 3 to 7 months of age as an accelerated heifer growth feeding program.

### **Why is a one ration approach popular?**

When feed prices are moderate and milk prices favorable, a number of reasons can be used to defend the use of one ration on dairy farms.

- Simplicity to mix and deliver one ration to the herd varying only the amount delivered
- Errors in adding the wrong amount of an ingredient
- Incorrect delivery of the specific ration to the intended group
- Labor saving by reducing the number of mixes
- Ability to top off feed bunks as needed

TMR mixer size becomes a factor depending on number of cows and feed delivery capacity. If more than one batch is needed, multiple rations become more viable.

### **Do cows drop in milk production when moved between groups?**

One controversial concern is the potential drop in milk production when cows are shifted from group to group. These factors should be considered:

- The change in nutrient content in the new ration
- Social impact of moving cows
- Impact on dry matter when shifting cow

The potential drop in dry matter intake after moving cows appears to be a risk when the lactation and dry matter intake curves have been established for the current lactation. Data from Illinois and Israel indicated if cows are moved before peak dry matter intake has been reached, the impact on milk production when moving cows is minimal. Social interactions (boss cow fighting, pecking order,

and feed bunk space) can lead to 3 to 8 pounds decreases in milk yield which may not recover. One strategy to reduce the potential drop in dry matter intake leading to lower milk yield is to increase nutrient intake with digestible fiber sources (such as soy hulls, corn gluten feed, or citrus pulp). This approach avoids changing the rumen environment and shifting nutrients to body weight gain and away from milk yield. Another field approach is to move cows in a consistent pattern (such as weekly) resulting in negative social interactions as groups do not stabilize. Cow moves could include moving far to close pen, close to fresh cow pen, fresh cow to early lactation pen, and early lactation pen to late lactation pen every week. If individual cow daily milk recording occurs, dairy managers can assess the impact of moving cows under their conditions.

### **What grouping alternatives can be considered?**

Dairy managers can group cows based on several factors. Once grouping pattern and alternatives have been determined, the decision to use one or multiple rations can be made. Several alternatives are listed below with guidelines favoring one ration or multiple rations.

- |   |                           |
|---|---------------------------|
| • First lactation cows and older cows             | One ration strategy       |
| • High producing and low producing cows           | Multiple rations strategy |
| • BSC (cows over 3.25 and cows under 3.25)        | Multiple rations strategy |
| • Open cows, bull pen, and/or pregnant cows       | One ration strategy       |
| • Low SCC and high SCC group                      | One ration strategy       |
| • Expensive feed additives                        | Multiple rations strategy |
| • Herds average 25 percent above state average    | One ration strategy       |
| • Herds with over 50 percent first lactation cows | One ration strategy       |
| • Herds experiencing metabolic disorders          | Multiple ration strategy  |
| • Herd with average days in milk over 225 days    | Multiple ration strategy  |

### **What are advantages with multiple ration approaches?**

The potential economic benefits increase as feed prices increase and milk prices decline. Feeding rations based on their physiological response can increase profitability by improving milk yield (such as early lactation cows) while avoiding health risks (late lactation cows). Cows in early lactation have the “drive” to produce milk and partition nutrients to higher milk yields (hormonal responses). Another ration lower in nutrient content for lower producing cows can improve profit margins by reducing feed costs while maintaining milk yield. Feed and nitrogen efficiency can be improved by shifting to a lower nutrient dense diet reducing nitrogen excretion and manure output.

A key advantage for multiple rations is the ability to manage body condition score without sacrificing milk yield. Heavy cows are high risk cows for metabolic disorders in the next lactation, impaired immune function, and delayed conception. Other factors to consider include the ability to get cows rebred (less than a 14 month calving interval), the availability to use rBST, and the percent of cows over a body condition score (BCS) of 3.75 at dry off time. If a one ration system is used resulting in heavy cows, shifting to a less fermentable and bulky ration using other feed ingredients may be needed (grass-legume forages and fibrous by-product feeds).

### **What is the economic impact when evaluating one or two rations?**

Key factors will be the price of milk, dry matter intake, price of dry matter per pound of dry matter, and anticipated change in milk yield. Two levels of milk production were selected (80 pounds for the high ration, and 60 pounds for the low ration) were compared using Midwest dairy feed ingredients and feed prices. Spartan II computer ration software was used to calculate least cost rations using the same ration ingredients. The results are listed below:

- 80 lb TMR costs \$6.15 per cow per day, 51.9 lb of dry matter, and 11.8 cents per pound of dry matter.
- 60 lb TMR cost \$4.90 per cow per day, 45.2 pounds of dry matter, and 10.8 cents per pound of dry matter.

The difference between the two rations represents \$1.25 per cow per day. However, the lower producing group consumed 6.7 pounds less dry matter compared to the high group. Because the low group consumed 6.7 pounds less dry matter at 11.8 cents per pound, the potential difference is 51 cents per cow per day ( $\$1.25 - \$0.74$ ). If milk production decline three pounds of milk, it would negate the cost savings). No feed additives or fat sources were included in either ration.

### **What lead factors can be used to decide a ration balancing point?**

Lead factors are the level of milk to balance rations above the herd or group average based on feed prices, milk prices, and herd characteristics (range in milk production in the group or herd, age of cows, and body condition status). Several alternatives are listed below.

- Virginia researchers suggested lead factors depending on the number of groups (values were rounded for ease of calculation):
  - One group or ration: Add 30 percent to the group average  
Example:  $70 \text{ lb} \times 30\% = 21 \text{ lb} + 70 \text{ lb} = 91 \text{ lb}$
  - Two groups or rations: Add 20 percent to the group average  
Example:  $80 \text{ lb} \times 20\% = 16 \text{ lb} + 80 \text{ lb} = 96 \text{ lb}$   
 $60 \text{ lb} \times 20\% = 12 \text{ lb} + 60 \text{ lb} = 72 \text{ lb}$
  - Three groups or rations: Add 10 percent to group average  
Example:  $90 \text{ lb} \times 10\% = 9 \text{ lb} + 90 \text{ lb} = 99 \text{ lb}$

$$70 \text{ lb} \times 10\% = 7 \text{ lb} + 70 \text{ lb} = 77 \text{ lb}$$
$$50 \text{ lb} \times 10\% = 5 \text{ lb} + 50 \text{ lb} = 55 \text{ lb}$$

- Calculate one standard deviation in milk yield for the group of cows (meeting the nutrient needs for two thirds of the cows in the group). This lead factor varied from 9 to 12 pounds of milk (middle to late lactation Holstein groups) to 17 to 20 pounds (early lactation Holstein groups).
- Add six pounds of milk to the lead factor for first lactation groups (growth factor for young cows).
- Add two pounds of milk to the lead factor for groups requiring an increase of 0.5 BCS in 200 days.

### **Are metabolic factors a consideration when building ration?**

Michigan workers suggest that highly fermentable rations can depress dry matter intake, increase BCS, and lead to milk test depression for lower producing cows as insulin drives glucose to be stored as body weight and reduces milk yield. Glucose demand for late lactation cows decline as milk lactose synthesis is lower (less milk produced). Because of insulin sensitivity and lower growth hormone secretion, late lactation cows drive circulating glucose to body condition gain from high fermentable rations.

High producing cows require more glucose (from highly fermentable rations leading to propionate production in the rumen converted to glucose in the liver and starch digestion in the lower tract) to synthesize lactose. These cows respond to rations with more fermentable carbohydrates (from digestible fiber, starch, and sugars) and less bulky ingredients (legume-grass forages) which can limit dry matter intake. High yielding cows have the ability to eat more dry matter unless feed intake is limited by gut fill (high fiber rations and rations lower in digestible fiber).

### **What role does forage quality have?**

The fill factor in a ration is determined by the level of fiber and digestibility of the forage. Research at Michigan State has demonstrated that a one unit increase in forage NDF digestibility (NDFD) increases milk yield by 0.55 pound of 3.5% fat corrected milk within a forage type. High producing cows responded to a greater extent with cows from 70 to 120 pounds of milk increasing from zero to two pounds of milk per unit increase in forage NDFD. Michigan workers also reported grass based forages had greater fill factors compared to high quality legume and corn silage forages due to slower passage rates with grass. Based on these studies, using grass and legume grass mixtures could be used by lower producing cows when gut fill is less important and can be metabolically favorable.

### **Selected References**

Allen, M. 2008. Time to regroup. Michigan Dairy Review.  
<https://www.msu.edu/~vol13no2/allen.html>

Hutjens, M.F. 2008. Feeding guide. 3<sup>rd</sup> Edition. Hoards Dairy Publications. Fort Atkinson, WI.

Spain, J. 1995. Management strategies for TMR feeding systems. 2<sup>nd</sup> Western Large Herd Mgmt Conf Proc. pp.162-168.

Stokes, S.R. 2001. Grouping strategies and their influence on farm profitability. International Nutrition Conf Proc. pp.129-139.

Table 1. Nutrient guidelines for one ration for high producing lactating dairy cows.

Nutrient	Suggested level
<u>Protein</u>	
Crude protein (%)	16.5 to 17.5
Metabolizable protein (%)	11 to 12
Soluble protein (% of crude)	28 to 34
Lysine (% MP)	6.6 to 7.2
Methionine (% MP)	2.2 to 2.4
<u>Fiber</u>	
Neutral detergent fiber (%)	28 to 34
Acid detergent fiber (%)	18 to 21
Lignin (%)	3 to 4
<u>Carbohydrate</u>	
Starch (%)	20 to 26
Sugar (%)	4 to 6
Fermentable fiber (%)	10 to 12
<u>Fat/oil (%)</u>	5 to 6

# The Effects of Heat Stress on Nutritional and Management Decisions

L.H. Baumgard and R.P. Rhoads  
Department of Animal Sciences  
The University of Arizona  
520-621-1487  
[baumgard@ag.arizona.edu](mailto:baumgard@ag.arizona.edu)

Heat stress negatively impacts a variety of dairy parameters including milk yield and reproduction and therefore is a significant financial burden (~\$900 million/year in the USA; St. Pierre et al., 2003) in many dairy-producing areas of the world. Advances in management (i.e. cooling systems; Armstrong, 1994; VanBaale et al., 2005) and nutritional strategies (West, 2003) have alleviated some of the negative impact of thermal stress on dairy cattle, but production continues to decrease during the summer. Accurately identifying heat-stressed cows and understanding the biological mechanism(s) by which thermal stress reduces milk synthesis and reproductive indices is critical for developing novel approaches (i.e. genetic, managerial and nutritional) to maintain production or minimize the reduction in dairy cow productivity during stressful summer months.

## Biological Consequence of Heat Stress

The biological mechanism by which heat stress impacts production and reproduction is partly explained by reduced feed intake, but also includes altered endocrine status, reduction in rumination and nutrient absorption, and increased maintenance requirements (Collier and Beede, 1985; Collier et al., 2005) resulting in a net decrease in nutrient/energy availability for production. This decrease in energy results in a reduction in energy balance (EBAL), and partially explains (reduced gut fill also contributes) why cows lose significant amounts of body weight when subjected to heat stress.

Reductions in energy intake during heat stress result in a majority of lactating cows entering into negative energy balance (NEBAL), and this is likely stage of lactation independent. Essentially, because of reduced feed and energy intake the dairy cow is putting herself in a bioenergetic state, similar (but not to the same extent) to the NEBAL observed in early lactation. The NEBAL associated with the early postpartum period is coupled with increased risk of metabolic disorders and health problems (Goff and Horst, 1997; Drackley, 1999), decreased milk yield and reduced reproductive performance (Lucy et al., 1992; Beam and Butler, 1999; Baumgard et al., 2002; 2006). It is likely that many of the negative effects of heat stress on production, animal health and reproduction indices are mediated by the reduction in EBAL (similar to the way it is during the transition period). However, it is not clear how much of the reduction in performance (yield and reproduction) can be attributed or accounted for by the biological parameters effected by heat stress (i.e. reduced feed intake vs. increased maintenance costs).

*This article has been adapted from a paper first published by the authors in the Proceedings in the 2007 Southwest Nutrition Conference and 2007 Cornell Nutrition Conference.*

## Heat Stress and Rumen Health

Heat stress has long been known to adversely affect rumen health. One way cows dissipate heat is via panting and this increased respiration rate results in enhanced CO<sub>2</sub> (carbon dioxide) being exhaled. In order to be an effective blood pH buffering system, the body needs to maintain a 20:1 HCO<sub>3</sub><sup>-</sup> (bicarbonate) to CO<sub>2</sub> ratio. Due to the hyperventilation induced decrease in blood CO<sub>2</sub>, the kidney secretes HCO<sub>3</sub><sup>-</sup> to maintain this ratio. This reduces the amount of HCO<sub>3</sub><sup>-</sup> that can be used (via saliva) to buffer and maintain a healthy rumen pH. In addition, panting cows drool and drooling reduces the quantity of saliva that would have normally been deposited in the rumen. Furthermore, due to reduced feed intake, heat-stressed cows ruminate less and therefore generate less saliva. The reductions in the amount of saliva produced and salivary HCO<sub>3</sub><sup>-</sup> content and the decreased amount of saliva entering the rumen make the heat stressed cow much more susceptible to sub-clinical and acute rumen acidosis (see review by Kadzere et al., 2002).

When cows begin to accumulate heat, there is a redistribution of blood to the extremities in an attempt to dissipate internal energy. As a consequence, there is reduced blood flow to the gastrointestinal track and nutrient uptake may be compromised (McGuire et al., 1989). Therefore, fermentation end products (VFAs) probably accumulate and contribute to the reduced pH.

Due to the reduced feed intake caused by heat stress and the heat associated with fermenting forages, nutritionists typically increase the energy density of the ration. This is often accomplished with extra concentrates and reductions in forages. However, this needs to be conducted with care as this type of diet can be associated with a lower rumen pH. The combination of a “hotter” ration and the cows reduced ability to neutralize the rumen (because of the reduced saliva HCO<sub>3</sub><sup>-</sup> content and increased drooling) directly increases the risks of rumen acidosis and indirectly enhances the risk of negative side effects of an unhealthy rumen (i.e. laminitis, milk fat depression, etc.).

## Metabolic Adaptations to Reduced Feed Intake

A prerequisite of understanding the metabolic adaptations which occur with heat stress, is an appreciation of the physiological and metabolic adaptations to thermal-neutral NEBAL (i.e. underfeeding or during the transition period).

Cows in early lactation are classic examples of when nutrient intake is less than necessary to meet maintenance and milk production costs and animals typically enter negative energy balance (Moore et al., 2005a). Negative energy balance is associated with a variety of metabolic changes that are implemented to support the dominant physiological condition of lactation (Bauman and Currie, 1980). Marked alterations in both carbohydrate and lipid metabolism ensure partitioning of dietary derived and tissue originating nutrients towards the mammary gland, and not surprisingly many of these changes are mediated by endogenous somatotropin which is naturally increased during periods of NEBAL (Bauman and Currie, 1980). One classic response is a reduction in circulating insulin coupled with a reduction in systemic insulin sensitivity. The reduction in insulin action allows for adipose lipolysis and mobilization of non-esterified fatty acids (NEFA; Bauman and Currie, 1980). Increased circulating NEFA are typical in “transitioning” cows and represent (along with NEFA derived ketones) a significant source of energy (and are precursors for milk fat synthesis) for cows in NEBAL. Post-absorptive carbohydrate metabolism is also altered by the reduced insulin action during NEBAL with the net effect of reduced glucose uptake by systemic tissues (i.e. muscle and

adipose). The reduced nutrient uptake coupled with the net release of nutrients (i.e. amino acids and NEFA) by systemic tissues are key homeorhetic (an acclimated response vs. an acute/homeostatic response) mechanisms implemented by cows in NEBAL to support lactation (Bauman and Currie, 1980). The thermal-neutral cow in NEBAL is metabolically flexible, in that she can depend upon alternative fuels (NEFA and ketones) to spare glucose, which can be utilized by the mammary gland to copiously produce milk.

### **Heat Stress and Production Variables**

Heat stress reduces both feed intake and milk yield and the decline in nutrient intake has been identified as a major cause of reduced milk synthesis (Fuquay, 1981). However, the exact contribution of declining feed intake to the overall reduced milk yield remains unknown. To evaluate this question, we utilized a group of thermal neutral pair-fed animals to eliminate the confounding effects of nutrient intake. Lactating Holstein cows in mid-lactation were either cyclically heat stressed (THI = ~80 for 16 hrs/d) for 9 days or remained in constant thermal neutral conditions (THI = ~ 64 for 24 hrs/d) but pair-fed with heat stressed cows to maintain similar nutrient intake. Cows were housed at the University of Arizona's ARC facility and individually fed ad libitum a TMR consisting primarily of alfalfa hay and steam flaked corn to meet or exceed nutrient requirements (NRC, 2001). Heat stressed cows had an average rectal temperature of ~105° F during the afternoons of the treatment implementation. Heat stressed cows had an immediate reduction (~5 kg/d) in dry matter intake (DMI) with the decrease reaching nadir at ~ day 4 and remaining stable thereafter (Figure 1). As expected and by design, thermal-neutral pair-fed cows had a feed intake pattern similar to heat stressed cows (Figure 1). Heat stress reduced milk yield by ~14 kg/d with production steadily declining for the first 7 days and then reaching a plateau (Figure 2). Thermal neutral pair-fed cows also had a reduction in milk yield of approximately 6 kg/d, but milk production reached its nadir at day 2 and remained relatively stable thereafter (Figure 2). This indicates the reduction in DMI can only account for ~40-50% of the decrease in production when cows are heat stressed and that ~50-60% can be explained by other heat stressed induced changes.

### **Metabolic Adaptations to Heat Stress**

Estimating EBAL during heat stress introduces problems independent of those that are inherent to normal EBAL estimations (Vicini et al., 2002). Considerable evidence suggest increased maintenance costs are associated with heat stress (7 to 25%; NRC, 2001), however due to complexities involved in predicting upper critical temperatures, no universal equation is available to adjust for this increase in maintenance (Fox and Tylutki, 1998). Maintenance requirements are increased, as there is a large energetic cost of dissipating stored heat. Not incorporating a heat stress correction factor results in overestimating EBAL and thus inaccurately predicting energy status.

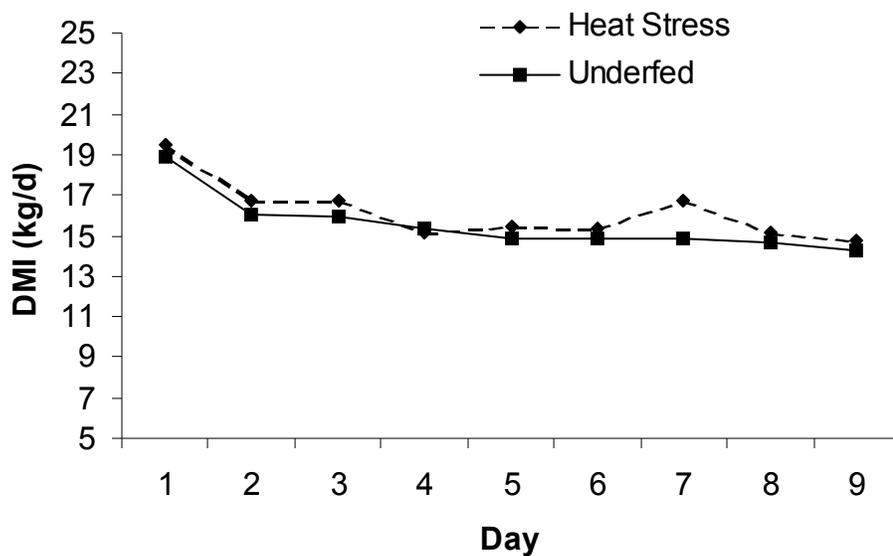


Figure 1. Effects of heat stress and pair-feeding thermal neutral lactating Holstein cows on dry matter intake. Rhoads et al., 2007

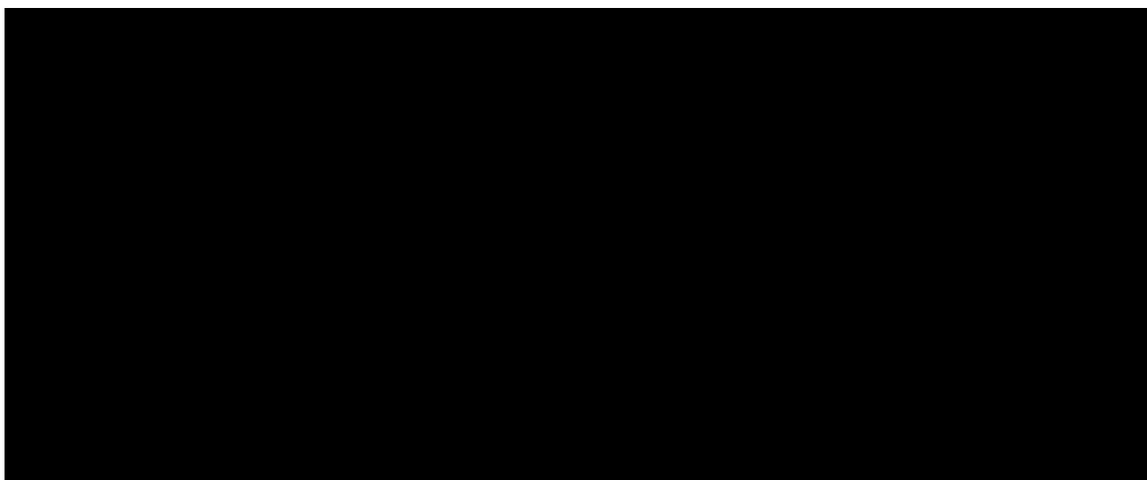


Figure 2. Effects of heat stress and pair-feeding thermal neutral conditions on milk yield in lactating Holstein cows. Rhoads et al., 2007.

Due to the reductions in feed intake and increased maintenance costs, and despite the decrease in milk yield heat stressed cows enter into a state of NEBAL (Moore et al., 2005b). In a similar trial as to the one described above, heat-stressed cows entered into and remained in NEBAL (~4-5 Mcal/d) for the entire duration of heat stress (Figure 3; Wheelock et al., 2006). However, unlike NEBAL in thermal neutral conditions, heat stressed induced NEBAL doesn't result in elevated plasma NEFA (Figure 4). This was surprising as circulating NEFA are thought to closely reflect calculated EBAL (Bauman et al., 1988). In addition, using an IV glucose tolerance test, we demonstrated that glucose disposal (rate of cellular glucose entry) is greater in heat stressed compared to thermal neutral pair-fed cows (Figure 5; Wheelock et al., 2006). Furthermore, heat-stressed cows have a much greater insulin response to a glucose challenge when compared to underfed cows (data not presented). Both the aforementioned changes in plasma NEFA and metabolic/hormonal adjustments in response to a glucose challenge can be explained by increased insulin effectiveness. Insulin is a potent antilipolytic signal (blocks fat break down) and the primary driver of cellular glucose entry. The apparent increased insulin action causes the heat-stressed cow to be metabolically inflexible, in that she does not have the option to oxidize fatty acids and ketones. As a consequence, the heat-stressed cow becomes increasingly dependant on glucose for her energetic needs and therefore less glucose is directed towards the mammary gland.

As stated earlier, the NRC (2001) arbitrarily indicates that mild to severe heat stress will increase maintenance requirements by 7 to 25% but indicates, "insufficient data are currently available to quantify these effects accurately". A typical lactating dairy cow will have a maintenance requirement of 9.7 Mcal/d (or 0.08 Mcal/kg BW<sup>0.75</sup>; NRC, 2001). In our experiment, ~8 kg of milk/d could not be explained by the reduction in feed intake (Figure 1 and 2) and this has an energetic value of approximately 6.1 Mcal/d (or 63% of a thermal neutral animals daily maintenance requirements). If all of the difference in milk synthesis (~8 kg/d) could be explained by the increase in maintenance requirements then heat-stressed cows would have an increase in maintenance requirements of 63%. However, we are currently unable to identify how much of the 8 kg of milk can be explained by enhanced maintenance needs, but if 25, 50 and 75% of the 6.1 Mcal/d was in fact utilized for increased maintenance, it would represent a 16, 31 and 47% increase in maintenance requirements, respectively. Deciphering how much of the milk yield differential can be explained by increased maintenance costs vs. other altered biological systems (i.e. reduced nutrient absorption, altered endocrine status etc.) is of primary interest.

Well-fed ruminants primarily oxidize (burn) acetate (a rumen produced VFA) as their principal energy source. However, during NEBAL cows also largely depend on NEFA for energy. Therefore, it appears the post-absorptive metabolism of the heat-stressed cow markedly differs from that a thermal-neutral cow, even though they are in a similar negative energetic state. The apparent switch in metabolism and the increase in insulin sensitivity is probably a mechanism by which cows decrease metabolic heat production, as oxidizing glucose is more efficient (Baldwin et al., 1980). In vivo glucose oxidation yields 38 ATP (assuming the  $\Delta G$  of ATP hydrolysis is -12.3 kcal/mole under cellular conditions; Berg et al., 2007) or 472.3 kcal of energy (compared to 637.1 kcal in a bomb calorimeter) and in vivo fatty acid oxidation (i.e. stearic acid) generates 146 ATP or 1814 kcal of energy (compared to 2697 kcal in a bomb calorimeter). Despite having a much greater energy content, due to differences in the efficiencies of capturing ATP, oxidizing

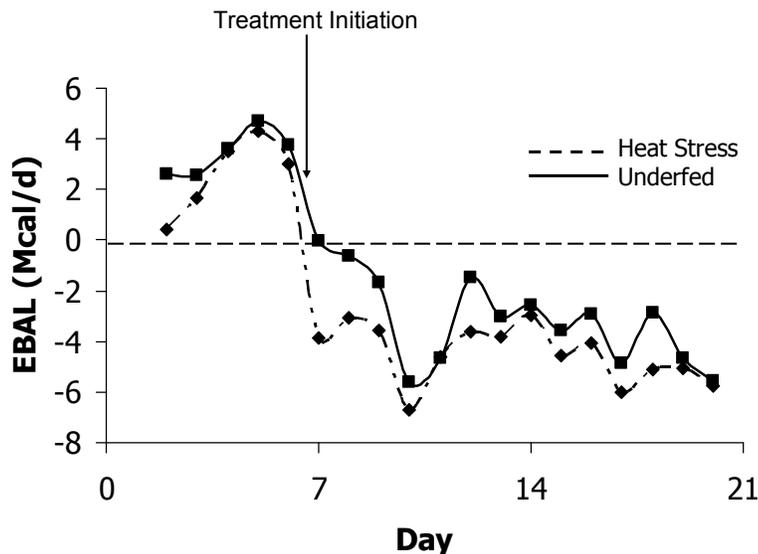


Figure 3. Effects of heat stress and pair-feeding thermal neutral conditions on calculated net energy balance in lactating Holstein cows. Adapted from Wheelock et al., 2006.

fatty acids generates more metabolic heat (~2 kcal/g or 13% on an energetic basis) compared to glucose. Therefore, during heat stress, preventing or blocking adipose mobilization/breakdown and increasing glucose “burning” is presumably a strategy to minimize metabolic heat production.

The mammary gland requires glucose to synthesize milk lactose and lactose production is the primary osmoregulator and thus determinant of milk yield. However, in an attempt to generate less metabolic heat, the body (primarily skeletal muscle) appears to utilize glucose at an increased rate. As a consequence, the mammary gland may not receive adequate amounts of glucose and thus mammary lactose production and subsequent milk yield is reduced. This may be the primary mechanism which accounts for the additional reductions in milk yield that cannot be explained by decreased feed intake (Figures 1 and 2).

In addition to heat stressed cows requiring special attention with regards to heat abatement and other dietary considerations (i.e. concentrate: forage ratio,  $\text{HCO}_3^-$  etc.) they also have an extra requirement for dietary or rumen-derived glucose precursors. Of the three main rumen-produced volatile fatty acids, propionate is the one primarily converted into glucose by the liver. Highly fermentable starches such as grains increase rumen propionate production, and although propionate is the primary glucose precursor, feeding additional grains can be risky as heat stressed cows are already susceptible to rumen acidosis.

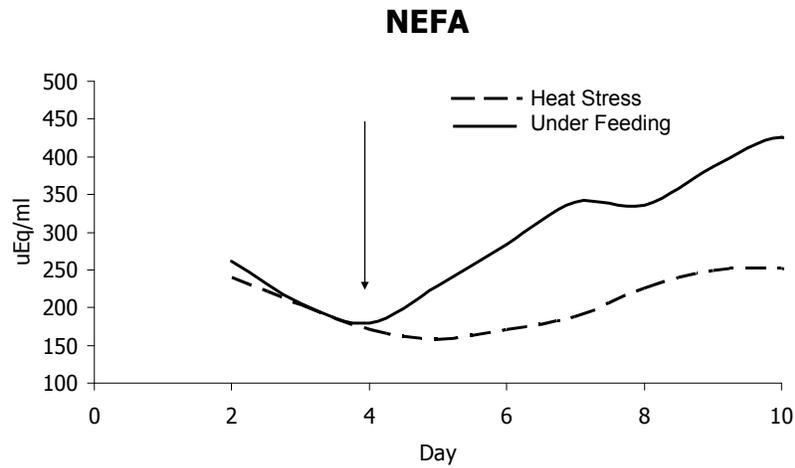


Figure 4. Effects of heat stress and pair-feeding thermal neutral conditions on circulating non-esterified fatty acids (NEFA) in lactating Holstein cows. Adapted from Wheelock et al., 2006.

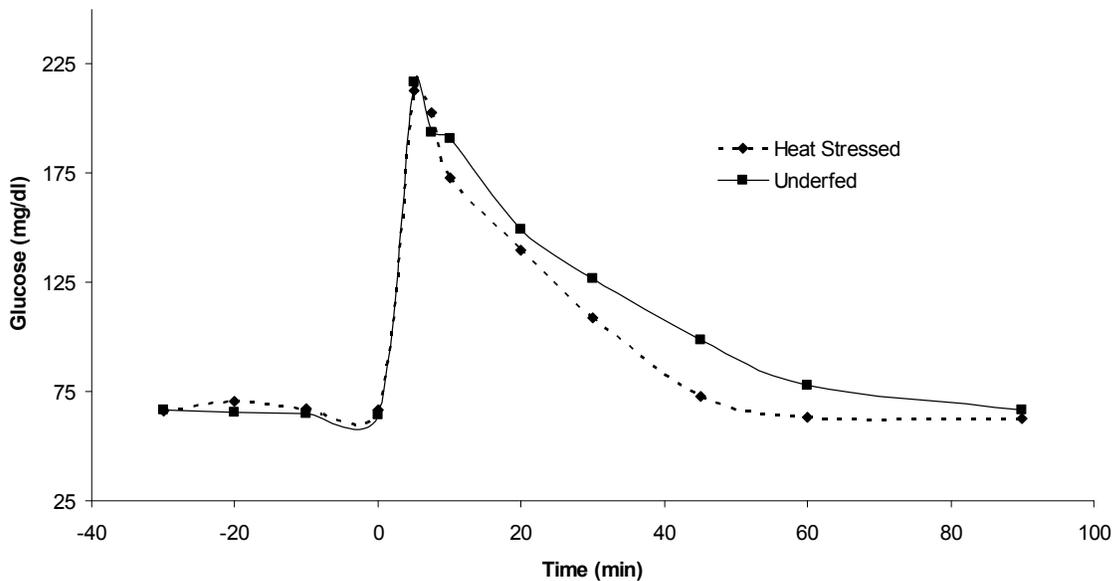


Figure 5. Effects of heat stress and pair-feeding thermal neutral conditions on plasma glucose response to a glucose challenge. Adapted from Wheelock et al., 2006.

### Practical Considerations

**Water:** Clearly, water intake is vital for milk production (milk is ~90% water) but it is also essential for thermal homeostasis. In contrast to common perception, heat-stressed cows remain well-hydrated (via large increases in water consumption; McDowell et al., 1969; Schneider et al., 1988, O'Brien and Baumgard, unpublished data) if they water is plentiful and clean. This illustrates how important water availability and waterer/tank cleanliness becomes during the summer months. Keeping water tanks clear of feed debris and algae is a simple and cheap strategy to help cows remain cool.

**Rumen Health:** As explained earlier, the heat-stressed cow is prone to rumen acidosis and many of the lasting effects of warm weather (laminitis, low milk fats etc.) can probably be traced back to a low rumen pH during the summer months. As a consequence, care should be taken when feeding “hot” rations during the summer months. In addition, obviously fiber quality is important all the time, but it is paramount during the summer as it has some buffering capacity and stimulates saliva production. Furthermore, although there is some academic controversy as to its effectiveness, dietary  $\text{HCO}_3^-$  may be a valuable tool to maintain a healthy rumen pH. Feeding supplemental direct fed microbials (DFMs) and/or yeast may also be strategy to help maintain a healthy rumen during heat stress. Some of these products help maintain rumen pH and stimulate feed intake and both would benefit the heat-stressed cow.

**Dietary Fat:** Despite the fact that it appears heat-stressed cows do not want to oxidize body reserves for energy, feeding dietary fat (rumen inert/rumen bypass) probably remains an effective strategy of providing extra (and safe with regards to rumen health) energy during a time of negative energy balance. Compared to starch and fiber, fat has a much lower heat increment in the rumen (Van Soest, 1982) and thus it can provide energy without a negative thermal side effect.

**Glucose:** Based upon some of our recent data, maximizing rumen production of glucose precursors (i.e. propionate) would be an effective strategy to maintain production. However, due to the rumen health issue, increasing grains should be conducted with care. A safe and effective method of maximizing rumen propionate production is with monensin (approved for lactating dairy cattle in 2004). In addition, monensin may assist in stabilizing rumen pH during stress situations (Schelling, 1984). Propylene glycol is typically fed in early lactation but may also be an effective method of increasing propionate production during heat stress. With the increasing demand for biofuels and subsequent supply of glycerol, it will be of interest to evaluate glycerols efficacy and safety in ruminant diets during the summer months.

**Protein:** The protein requirement of the heat-stressed lactating cow is an area that needs additional research. Protein is typically one of the most expensive dietary components and deaminating (removing excess nitrogen) protein generates a lot of metabolic heat, and these are two important reasons why not to overfeed protein to a heat-stressed cow.

**DCAD:** Having a negative DCAD during the dry period and a positive DCAD during lactation is a good strategy to maintain health and maximize production (Block, 1994). It appears that keeping the DCAD at a healthy lactating level (~+20 to +30 meq/100 g DM) remains a good strategy during the warm summer months (Wildman et al., 2007).

**Minerals and Vitamins:** Unlike humans, bovines utilize potassium ( $\text{K}^+$ ) as their primary osmotic regulator of water secretion from their sweat glands. As a consequence,  $\text{K}^+$  requirements are

increased (1.4 to 1.6% of DM) during the summer and this should be adjusted for in the diet (West, 2002). In addition, dietary levels of sodium ( $\text{Na}^+$ ) and magnesium ( $\text{Mg}^+$ ) should be increased as they compete with  $\text{K}^+$  for intestinal absorption (West, 2002). Niacin is a well-known subcutaneous vasodilator in a variety of species (humans taking supplemental niacin often experience “flushing” in the face). We have preliminary evidence demonstrating that supplementing rumen protected niacin decreases body temperature indices in lactating cows experiencing moderate heat stress (Burgos-Zimbelman et al., 2008) and this is presumably via an increased ability to dissipate heat.

***Feeding Times, Locking Up, Holding Pens and Dry Cows:*** Cows are often lethargic during the hottest parts of the day, therefore changing the feeding schedule to coincide with the cooler parts of the day (i.e. early morning and late in the evening) may be a good strategy. In addition, although pushing up often and removing old feed is always a good policy, they are even more important during the warm periods of the year. Locking up cows during peak heat (especially if the lock up does not have shade) should be avoided and if it can not, then minimizing the time cows are locked up is obviously a good idea. The holding pen is a consistent place on almost every dairy where cows are crowded and where the humidity is high. Both criteria diminish the ability to dissipate body heat and body temperature is often highest in this pen. Minimizing the time spent in the holding pen and investing in cooling infrastructure may pay dividends. The dry cow consumes less feed and produces less metabolic heat and thus some have incorrectly assumed they are less susceptible to heat stress. However, dry cows ARE sensitive to heat stress and without proper cooling (at least shade) they will 1) deliver calves early, 2) have reduced milk yield in the subsequent lactation and 3) have reduced reproductive parameters in the next lactation (even if they are well-cooled following parturition; Armstrong, 1994).

***rbST:*** Somatotropin treated cows produce more milk and consequently consume more feed to sustain the increase in production. Both parameters cause cows to generate more metabolic heat but this extra heat is counterbalanced by increased heat dissipation and therefore body temperature indices are not elevated (Collier et al., 2005). Some have suggested that heat-stressed cows do not respond, or do not respond as well (with regards to milk yield) to supplemental bST during the summer months, but we have recently demonstrated that rbST increases milk yield (~15%) even in severely heat-stressed (rectal temperatures  $> 104.0^\circ\text{F}$ ) dairy cows (Wheelock et al., 2006). The mechanisms by which rbST increases milk yield is similar between thermal neutral and heat-stressed cows and the biological changes induced by heat stress do not prevent rbST from remaining effective.

## Summary

Clearly the heat-stressed cow implements a variety of post-absorptive changes in both carbohydrate and lipid metabolism (i.e. increased insulin action) that wouldn't be predicted based upon their energetic state. The primary end result of this altered metabolic condition is that the heat-stressed lactating dairy cow has an extra need for glucose (due to its preferential oxidization by extra-mammary tissue). Therefore, any dietary component that increases propionate production (the primary precursor to hepatic glucose production), without reducing rumen pH, will probably increase milk yield. In addition, reducing systemic insulin sensitivity will increase glucose availability to the mammary and thus also probably increase milk yield.

## References

- Armstrong, D.V. 1994. Heat stress interaction with shade and cooling. *J. Dairy Sci.* 77:2044-2050.
- Baldwin, R.L., N.E. Smith, J. Taylor, and M. Sharp. 1980. Manipulating metabolic parameters to improve growth rate and milk secretion. *J. Anim. Sci.* 51:1416-1428.
- Bauman, D.E. and W.B. Currie. 1980. Partitioning of nutrients during pregnancy and lactation: a review of mechanisms involving homeostasis and homeorhesis. *J. Dairy Sci.* 63:1514-1529.
- Bauman, D.E., C.J. Peel, W.D. Steinhour, P.J. Reynolds, H.F. Tyrrell, C. Brown, and G.L. Harland. 1988. Effect of bovine somatotropin on metabolism of lactating dairy cows: influence on rates of irreversible loss and oxidation of glucose and nonesterified fatty acids. *J. Nutr.* 118:1031-1040.
- Baumgard, L.H., C.E. Moore, and D.E. Bauman. 2002. Potential application of conjugated linoleic acids in nutrient partitioning. *Proc. Southwest Nutr. Conf.* pp 127-141.
- Baumgard, L.H., L.J. Odens, J.K. Kay, R.P. Rhoads, M.J. VanBaale and R.J. Collier. 2006. Does negative energy balance (NEBAL) limit milk synthesis in early lactation? *Proc. Southwest Nutr. Conf.* 181-187.
- Beam, S.W., and W.R. Butler. 1999. Effects of energy balance on follicular development and first ovulation in postpartum dairy cows. *J. Reprod. Fertility* 54:411-424.
- Berg, J.M., J.L. Tymoczko and L. Stryer. *Biochemistry*. 6<sup>th</sup> Edition. W.H. Freeman.
- Block, E. 1994. Manipulation of dietary cation-anion difference on nutritionally related production diseases, productivity, and metabolic responses of dairy cows. *J. Dairy Sci.* 77:1437-1450.
- Burgos-Zimbelman, R., J. Collier, M.B. Abdallah, L.H. Baumgard, T.R. Bilby and R.J. Collier. 2008. Improving resistance to thermal stress in dairy cows with protected niacin. *Proc. Southwest Nutr. Conf.* 114-126.
- Collier, R.J., L.H. Baumgard, A.L. Lock and D.E. Bauman. 2005. Physiological Limitations: nutrient partitioning. Chapter 16. In: *Yields of farmed Species: constraints and opportunities in the 21<sup>st</sup> Century*. Proceedings: 61<sup>st</sup> Easter School. Nottingham, England. J. Wiseman and R. Bradley, eds. Nottingham University Press, Nottingham, U.K. 351-377.
- Collier, R.J., and D.K. Beede. 1985. Thermal stress as a factor associated with nutrient requirements and interrelationships. In *Nutrition of Grazing Ruminants*. (ed) by L. McDowell. Academic Press, New York, NY. pp 59-71.
- Drackley, J.K. 1999. Biology of dairy cows during the transition period: the final frontier? *J. Dairy Sci.* 82:2259-2273.
- Fox, D.G. and T.P. Tylutki. 1998. Accounting for the effects of environment on the nutrient requirements of dairy cattle. *J. Dairy Sci.* 81:3085-3089.

- Fuquay, J.W. 1981. Heat stress as it affects production. *J. Anim. Sci.* 52:167-174.
- Goff, J.P. and R.L. Horst. 1997. Physiological changes at parturition and their relationship to metabolic disorders. *J. Dairy Sci.* 80:1260-1268.
- Kadzere, C.T., MR. Murphy, N. Silanikove and E. Maltz. 2002. Heat stress in lactating dairy cows: a review. *Livestock Prod. Sci.* 77:59-91.
- Lucy, M.C., C.R. Staples, W.W. Thatcher, P.S. Erickson, R.M. Cleale, J.L. Firkins, J.H. Clark, M.R. Murphy and B.O. Brodie. 1992. Influence of diet composition, dry matter intake, milk production and energy balance on time of postpartum ovulation and fertility in dairy cows. *Anim. Prod.* 54:323-331.
- McDowell, R.E., E.G. Moody, P.J. Van Soest, R.P. Lehmann and G.L. Ford. 1969. Effect of heat stress on energy and water utilization of lactating cows. *J. Dairy Sci.* 52: 188-194.
- Moore, C.E., J.K. Kay, M.J. VanBaale and L.H. Baumgard. 2005a. Calculating and improving energy balance during times of nutrient limitation. *Proc. Southwest Nutr. Conf.* 173-185.
- Moore, C.E., J.K. Kay, M.J. VanBaale, R.J. Collier and L.H. Baumgard. 2005b. Effect of conjugated linoleic acid on heat stressed Brown Swiss and Holstein cattle. *J. Dairy Sci.* 88:1732-1740.
- National Research Council. 2001. *Nutrient Requirements of Dairy Cattle*, 7<sup>th</sup> rev. ed. Nat. Acad. Press, Washington, DC.
- Rhoads, M.L, R.P. Rhoads, S.R. Sanders, S.H. Carroll, W.J. Weber, B.A. Crooker, R.J. Collier, M.J. VanBaale and L.H. Baumgard. 2007. Effects of heat stress on production, lipid metabolism and somatotropin variables in lactating cows. *J. Dairy Sci.* 90. Suppl. (1):230 (abst.).
- Schelling, G.T. 1984. Monensin mode of action in the rumen. *J. Anim. Sci.* 58:1518-1527.
- Schneider, P.L., D.K. Beede, and C.J. Wilcox. 1988. Nycterohemeral patterns of acid-base status, mineral concentrations and digestive function of lactating cows in natural or chamber heat stress environments. *J. Anim. Sci.* 66:112-125.
- St. Pierre, N.R., B. Cobanov, and G. Schnitkey. 2003. Economic losses from heat stress by US livestock industries. *J. Dairy Sci.* 86:E52-E77.
- VanBaale, M.J., J.F. Smith, M.J. Brouk, and L.H. Baumgard. 2005. Evaluate the efficacy of your cooling system through core body temperature. *Hoard's Dairyman: Western Dairy News.* Aug 5:W147-W148.
- Van Soest, P.J. 1982. *Nutritional ecology of the ruminant.* O & B Books, Inc.
- Vicini, J.L., B.A. Crooker and M.A. McGuire. 2002. Energy balance in early lactation dairy cows. *CA. Anim. Nutr. Conf.* 1-8.

West, J.W. 2002. Physiological effects of heat stress on production and reproduction. Proc. Tri-State Nutr. Conf. 1-9.

West, J.W. 2003. Effects of heat-stress on production in dairy cattle. J. Dairy Sci. 86:2131-2144.

Wheelock, J.B., S.R. Sanders, G. Shwartz, L.L. Hernandez, S.H. Baker, J.W. McFadden, L.J. Oden, R. Burgos, S.R. Hartman, R.M. Johnson, B.E. Jones, R.J. Collier, R.P. Rhoads, M.J. VanBaale and L.H. Baumgard. 2006. Effects of heat stress and rbST on production parameters and glucose homeostasis. J. Dairy Sci. 89. Suppl. (1):290-291 (abst.).

Wildman, C.D., J.W. West, and J.K. Bernard. 2007. Effect of dietary cation-anion difference and dietary crude protein on performance of lactating dairy cows during hot weather. J. Dairy Sci. 90:1842-1850.

# Feeding \$10 Corn for Fun and Profits

Normand St-Pierre, Ph.D., P.A.S.  
Professor, Department of Animal Sciences  
The Ohio State University  
2029 Fyffe Court, 221 Animal Science Bldg.,  
Columbus, OH-43210-1995, (  
614) 292-6507,  
FAX (614) 292-1515,  
Email: st-pierre.8 @osu.edu

## Take Home Message

1. The sudden feed price increases that we have experienced in the last two years are likely to be with us for the long-term, although strong price fluctuations are likely to occur in the short-term and well into the future unless there were to be radical changes in U.S. food and energy policies. Producers must learn to deal with this changed landscape.
2. Growing cost-efficient feeds such as corn silage affects directly the bottom-line. The selection of high-yielding, high-quality hybrids and varieties can substantially affect feed costs over the next 12 months.
3. If you grow a high-quality forage, it is critical to maintain its quality during harvest and storage. Optimal harvest time, kernel processors, effective silage inoculants, quick ensiling, intense packing, and effective covering of the silo are time-proven technologies and practices that have seen their economic values doubled in the last two years.
4. You can't keep purchasing the same feeds all the time! Feed markets change and a producer must periodically assess the economic value of the feeds being purchased.
5. Feeds should be used with predictable efficiency by the cows. The goal is not to achieve a very high feed efficiency (this can in fact be costly) but to achieve an optimum feed efficiency. A producer must measure what is actually being fed to monitor feed efficiency.
6. Verify that your feeding program is economically competitive. Calculate your income-over-feed costs and compare it to the Cow-Jones Index to determine your competitiveness.
7. Get the cows bred and keep the barn full.

## Introduction

Feed costs have always been a dominant portion of the cost of producing milk in the United States. The unprecedented, nearly insane rise in market prices of all feedstuffs that has occurred in the U.S. in 2007 and 2008 has stimulated much interest in feed management and measures of the economic efficiency of feed use on dairy farms. A few years ago, \$3/bu corn occurred sporadically following a disastrous crop year. We all knew then that corn would soon fall back in the \$2/bu price range.

But 2007 brought us \$3.50/bu corn with little hope for price reductions even in the long-term. Still, \$6/bushel corn seemed impossible. Little did we know that spring 2008 was going to take care of this mental barrier. And few foresaw the corn and soybean prices meltdown that we experienced in mid-summer 2008. So what's next? Will we see \$10/bu corn next winter, or will it be \$2/bu? Are the futures markets really good predictors of the prices to come?

Whether we see \$10/bu or \$2/bu corn should not be vital to the management of a dairy farm. Clearly, high corn price would have brutal economic consequences – profitability certainly would be severely impacted, but the fact that we have permanently entered a new era of higher and more volatile feed prices should be sufficient in itself to justify a critical evaluation of one's entire feeding program. At a minimum, this entails:

1. Growing cost-efficient feeds,
2. Preserving the value of the harvested crops,
3. Purchasing the right feeds,
4. Targeting optimal feed efficiency from balanced diets, and
5. Ensuring “nutrition” competitiveness.

### **Growing Cost-Efficient feeds**

For most farms in the U.S., this implies a greater proportion of crop acres dedicated to corn silage as opposed to grass and legumes. Although alfalfa contains considerably more crude protein than corn, most of the protein is highly soluble and, consequently, rumen-degradable. Over the years, the economic value of rumen-degradable protein (**RDP**) has declined markedly. Currently, it is pretty much worthless. So the additional protein in alfalfa is really not worth much, if anything at all. Corn silage, however, contains substantially more energy than either grass or alfalfa. The cost of dietary energy in dairy cow rations has nearly tripled in the last two years. Thus, a high energy forage such as corn silage is worth considerably more per ton than a medium or low energy forage. In addition, corn silage is a highly mechanized crop and is much less susceptible to the vagaries of the weather during growth and harvest than most other forage crops.

Regardless of the crop, the hybrid and variety selection is much more important now than in the past. The last decade has brought incredible innovations in plant breeding and genetics. There are vast differences between corn hybrids and plant varieties that affect dramatically yield and quality. In corn silage production, the right hybrid at the right place can significantly affect a dairy farm's bottom line.

### **Preserving the Value of the Harvested Crops**

Harvesting at the right stage of maturity affects the quality of both haycrops and corn silages. At each cutting, the window of time for the optimal harvest of alfalfa is very short. Each day past the optimal cutting stage results on an average in a 1% drop in forage dry matter digestibility. Using today's prices, each day that the harvest is delayed past the optimal cutting time results in a \$2.00-\$3.00 per ton drop in the value of alfalfa hay.

Corn silage is generally more forgiving regarding optimal stage for harvest. With bunker silos, total plant moisture in the 65-68% range at harvest results in optimal digestibility and intake. This range

generally provides a one week window for optimum harvest. The use of a kernel processor at harvest can lengthen the optimal window. Its effect can be noticeable when whole plant moisture drops under 65%.

Because the quality of the silage can deteriorate rapidly once the plant is chopped, it is very important to fill the silos quickly, to treat with an effective silage inoculant, to sufficiently pack bunker silos, and to cover the silo with an effective air barrier (plastic sheet) properly weighted down (discarded tires or other effective devices). Because of the increase in feed prices, the value of these practices and technologies has at least doubled in the last two years. So if they were cost efficient two years ago, imagine what their return is right now!

### **Purchasing the Right Feeds**

Feed ingredients are constantly jockeying for a position in dairy rations. But markets are in constant fluxes; supply and demand keep changing. What may have been a bargain months ago may now be overpriced. A few years ago, we designed a new method for comparing feeds based on their market prices. The method has been computerized in a Windows-based software named *Sesame*<sup>2</sup>.

As an example, Figure 1 reports the results for central California in mid-January 2009. These specific results are only applicable to central California, and only in mid-January 2009. I write a regular column on this topic in the Ohio State dairy newsletter (Buckeye Dairy News – accessible at <http://dairy.osu.edu>). Numerically, results would be different for Idaho or Wisconsin for example, but the conclusions reached would not be markedly different.

In Figure 1, the column labeled ‘Actual’ list the prevailing market prices for California in mid January (bulk, TTL delivered). The column labeled ‘Predicted’ reports the break-even prices calculated by *Sesame*. Hence, one can find in this table that rolled barley and canola meal are two feed ingredients that were particularly overpriced, whereas rice bran or distillers dried grains were definite bargains.

Periodically, producers should use a tool such as *Sesame* to determine whether what they are currently purchasing is predominantly in the bargain column as opposed to the over-priced one.

### **Targeting optimal feed efficiency from balanced diets**

A nutritionally balanced diet should perform according to nutritional expectations. That is, the conversion of feeds into milk should be done with an efficiency that is predictable.

During the 1990’s, it was often stated that the first objective of nutrition management and feed formulation was to maximize feed intake of lactating dairy cows. This dogma was derived from the strong association (correlation) between daily dry matter intake (**DMI**) and milk production. Of course, this interpretation was incorrect because a correlation (or simple regression) does not imply a cause and effect. Over time, field observations of DMI that were disproportionately high to milk production levels were being reported, raising concerns about the validity of the “maximize DMI” dogma. I remember all too well visiting a herd where apparent daily DMI exceeded daily milk

---

<sup>2</sup> Available at [www.sesamesoft.com](http://www.sesamesoft.com)

production. Gradually, this dogma was replaced by one based on gross feed efficiency (GFE), which at first was simply expressed as pounds of milk per unit of DMI, and later replaced by slightly more complex measures such as pounds of 3.5% fat-corrected milk or energy-corrected milk per pound of DMI. Unless one is facing a situation of milk production with abnormally low or high fat content, the use of any of these energy corrected feed ratios generally leads to the same (and sometimes erroneous) conclusions as the simple GFE based on raw milk production.

There are some issues associated with the interpretation of the GFE.

***Effect of stage of lactation on gross feed efficiency.*** Figure 2a presents typical lactation and DMI curves for a 1,500 lb cow in her third lactation, producing 22,000 lbs of milk per year with an average fat and true protein contents of 3.60 and 3.10%, respectively. Milk production peaks at 101 lbs/d at 50 day in milk (**DIM**), while DMI peaks at 58.5 lbs/d at 80 DIM.

Figure 2b shows the calculated GFE over the course of the lactation. Predictably, GFE is the highest in early lactation (2.21 in the first month), decreasing gradually over the lactation cycle to reach a value of 0.78 in the eleventh month. After the third month of lactation, the decline in GFE over time is nearly linear, dropping 0.11 unit per month of lactation (0.0037 unit per day). Over the entire lactation, GFE averages approximately 1.4, a value about equal to the GFE at 150 DIM. Because of the significant effect of DIM on GFE, it seems important that the benchmark be adjusted for DIM in herds that do not have uniform calvings throughout the year. Essentially, the benchmark should be reduced by 0.11 units for each month that the average DIM exceeds 150 d.

This also points out the importance of getting the cows bred. For each month that conception is delayed, the herd is expected to lose 0.11 point of feed efficiency. Using an average feed cost of \$0.10/lb of dry matter, this means that a herd with an average DIM of 150d would be consuming  $100 \div 1.4 = 71.4$  lbs of feed DM per cwt produced, equating to a feed cost of \$7.14/cwt. In contrast, a herd at 180 DIM would be consuming  $100 \div 1.29 = 77.5$  lbs of feed DM per cwt produced, equating to a feed cost of \$7.75/cwt. The additional 30 days open costs the whole herd  $\$7.75 - \$7.14 = \$0.61$ /cwt produced. In a herd of 2000 cows producing 22,000 lbs/year, the additional 30 days open results in a decreased profit of \$268,000/year!

***Effect of milk production level on gross feed efficiency.*** In theory, increased productivity should be associated with increased GFE due to the dilution of the maintenance requirements. In Figure 3, we calculated the GFE over a lactation cycle at three levels of production: 16,000, 22,000, and 28,000 lbs/year. The average GFE over the lactation cycle drops from approximately 1.6 to 1.4 when production is reduced from 28,000 to 22,000 lbs/year, and to 1.15 when production is further reduced to 16,000 lbs/year. Animal production has a profound effect on the expected GFE. If GFE is to be used as some sort of efficiency benchmark, it is clear that the target must be adjusted for the level of production in a herd. Whether the actual level of production is optimal is a very different question than whether the animals are converting feeds according to nutritional (physical) expectations.

***Effects of ration energy density.*** The calculations done so far assume that the diets are formulated according to NRC requirements. For example a 1,500 cow producing 75 lbs/d of milk at 3.6% fat, 3.1% protein, and 5.7% other solids has a total  $NE_L$  requirement of 34.7 Mcal/d and is expected to

consume 51.8 lbs of DMI per day, thus requiring a diet with an energy density of 0.67 Mcal/lb to attain a zero energy balance. Changing the energy density of the diet would likely alter DMI. We know enough about cows to calculate the expected GFE for diets of different energy densities (Table 1). Over a range of reasonable diet NE<sub>L</sub> densities (0.65 to 0.74 Mcal/lb), GFE varies by nearly 0.2 units. Depending on the relative costs of grains, forages, and fats, increasing the energy density above the implied energy density “requirement” does improve GFE, but this may lead to reduced income. The important point here is to remember that **the objective should NOT be to maximize feed efficiency but to achieve a feed efficiency in line with the expectations.**

***Setting up meaningful gross feed efficiency benchmarks.*** In Table 2, we propose target GFE for Holstein cows at different levels of milk production. If milk production is expressed in lbs of milk/cow per day (i.e., milk production for a herd - or for a pen - is at a given point in time) then the target GFE is read directly from the table. For example, a pen of cows milking 80 lbs of milk per day has a GFE benchmark of 1.54. If milk production is expressed as rolling herd average or other forms of annual production, then the benchmark GFE must be adjusted based on the current average days in milk of the herd (or pen) as explained previously. For example, a herd with a 22,000 lbs RHA at 180 DIM would have a target GFE of 1.4 (from the table) – 0.11 (to account for the month deviation in DIM from 150 d) = 1.29. In either case, because measurements of both production and DMI are subject to errors, deviations of actual GFE from target GFE of less than 0.05 unit should be ignored, while deviations of less than 0.10 unit should probably not be of any great concern. Of course, monitoring GFE is a worthless activity unless one ensures relatively accurate and precise measurements of both milk production and DMI.

### ***Diagnostics and interventions.***

Measured GFE is greater than target GFE (feed efficiency seems too good to be true):

1. Some diet components may have an actual energy concentration greater than the value used in feed formulation. You may consider gradually replacing some of the more expensive, energy dense ingredients by cheaper and less energy dense feeds.
2. Are the cows losing an excessive amount of weight and condition score? If so, you'll be paying back later with much added interest... Physical factors such as rumen fill or other management factors could be limiting intake. The digestibility of the diet and/or its energy density may need to be raised.
3. Verify the numbers. Forage moisture may in fact be less than values used for diet formulation. Also, ensure that the correct head count was used to calculate DMI.
4. Verify the feed (mixer) scale.

Measured GFE is less than target GFE (feed efficiency seems bad)

1. Are the cows gaining an excessive amount of weight and body condition? If so, this indicates a fundamental problem with the diet or the management of the animals. Somebody needs to intervene.

2. Some diet components may in fact have a lower energy concentration than the one used for balancing the diet. For example, forages may not be as digestible as calculated. Try increasing the ration energy density if at all possible.
3. Verify the numbers. Forage moisture may be greater than the value used for balancing the diet. Verify the head count used for calculating DMI. Ensure that intake is solely for lactating dairy cows and does not include dry cows, pre-fresh cows, shortly fresh cows, or even replacement heifers. Sometimes, DMI is based on the amount of feed offered and has not been corrected for feed refusal and wastage.

### Ensuring Nutrition Competitiveness

Whereas physical feed efficiency tries to answer the question “are the cows processing (digesting) the diet in line with what should be expected?”, economic feed efficiency attempts at answering “is the feeding program economically optimal; is it competitive?”. It is important to note here that the objective should *never* be to minimize feed costs per hundredweight of milk. Although not quite correct, the maximization of income-over-feed-costs (**IOFC**) acts as a reasonable target for management.

We are all aware of the striking gyrations of milk prices in the U.S. over the last decade. Figure 4 shows adjusted Class III milk prices in FMMO from January 2005 through October 2008. Milk prices averaged \$15.29/cwt, with a minimum of \$11.17/cwt in May of 2006 and a maximum of \$22.00/cwt in July 2007. What is often forgotten is that in most FMMO, milk is now component priced. That is, most of the mailbox price is in fact determined by prices and milk composition for fat, protein, and other solids (**OS**). Figure 5 reports the evolution of fat, protein and OS prices over the same period of January 2005 through October 2008. This figure makes evident that much of the substantial increases in milk prices experienced in 2007 were due to sharp increases in milk protein prices and to a lesser extent to OS prices.

For a long time, the USDA has tracked a measure of economic efficiency using the milk-to-feed (**MTF**) ratio, essentially the ratio of the price of a cwt of milk (numerator) to the cost of 50 lbs of corn, 8 lbs of whole soybeans, and 41 lbs of hay (denominator). For some reasons, economists like to bring almost everything into a ratio. The MTF fails to be a reliable benchmark of profitability for many reasons, most importantly because it is a *ratio* of two entities, whereas profitability is the *differences* between two entities (net income = revenues minus expenses). We have proposed a new benchmark based on the difference between milk revenues and the costs of providing the required nutrients. This benchmark is completely dissociated from any specific diet. *Sesame* is used to calculate the cost of the nutrients and the requirements are calculated using the National Research Council tables of nutrient requirements.

Figure 6 shows the evolution of unit costs for net energy for lactation (**NE<sub>L</sub>**), metabolizable protein (**MP**), and effective NDF (**e-NDF**) during the period of January 2005 through October 2008 for the midwest (ne-NDF costs are not presented because they didn't vary much during this period of time). From this figure, it is evident that the rises in feed prices experienced over the last 18 months have translated, as expected, in increased unit costs of nutrients, although nutrients have shown different patterns over time.

**Calculating the benchmarks.** Table 3 shows in details how the economic efficiency benchmark is calculated, using price and cost figures for February 2008. A spreadsheet to assist making these calculations (Cow-Jones-Index.xls) can be downloaded at <http://dairy.osu.edu>.

The primary outcome of these calculations is what we have facetiously named the *Cow-Jones Index (CJI)*. Just as people can track the performance of their stocks investments by comparing their returns to the Dow-Jones Index, dairy producers and their nutritionists can now compare over time their nutrition costs and milk revenues to an index that summarizes the movement of both the milk and the feed markets (Figures 7 and 8).

**Diagnosics and intervention.** When a herd's IOFC deviates substantially from the CJI, the following questions must be addressed:

1. Are you growing or buying the right feeds? *Sesame* can be used to answer this question.
2. Are you buying competitively (i.e., are you a good buyer)?
3. Are you assembling the correct diet? Are feed put in the right combination?
4. What DMI are you using, the one on the feeding chart or the one actually consumed?
5. Who pays for feed refusals? Who pays for feed shrink?
6. What costs are you using? Are forage priced based on their total costs of production (including storage) or just variable costs?
7. Are feed converted to milk as expected (i.e., is the GFE near its target)?

#### **Other non-feed actions**

1. Get cows pregnant. We calculated the additional feed consumed per cwt of milk due to additional days open. The total economic losses due to poor reproduction are in fact much greater than just the additional feed costs. It takes the same amount of labor (and parlor capital) to milk a cow producing 50 lbs/d compared to a cow producing 100 lbs/d. So many other costs when expressed per cwt go up with poor production and reproduction.
2. Keep the barn full. The depreciation and barn maintenance costs the same whether the barn is full or half-full. Recently, I have seen many small and medium sized herds with unfilled barns. This can get very costly very rapidly.

**Table 1.** Effect on ration net energy for lactation (NE<sub>L</sub>) density on target gross feed efficiency (GFE) for Holstein cows producing 75 lbs/d of milk at 3.6% fat, 3.1% protein, and 5.7% other solids.

NE <sub>L</sub> (Mcal/lb)	DMI (lbs/d)	Target GFE	Forage (% of DMI) <sup>1</sup>	Forage (lbs/d)	Grain (lbs/d)
0.65	53.4	1.40	66.7	35.6	17.8
0.66	52.6	1.43	63.3	33.3	19.3
0.67	51.8	1.45	60.0	31.1	20.7
0.68	51.0	1.47	56.7	28.9	22.1
0.69	50.3	1.49	53.3	26.8	23.5
0.70	49.6	1.51	50.0	24.8	24.8
0.71	48.9	1.53	46.7	22.8	26.1
0.72	48.2	1.56	43.3	20.9	27.3
0.73	47.5	1.58	40.0	19.0	28.5
0.74	46.9	1.60	36.7	17.2	29.7

<sup>1</sup> Forage and grain amounts are calculated assuming an NE<sub>L</sub> of 0.55 Mcal/lb for forage and 0.85 Mcal/lb for grain. Shaded cells are according to NRC (2001).

**Table 2.** Target gross feed efficiency (GFE) for Holstein herds at various levels of milk production expressed either as rolling herd average (RHA) or average daily milk production.

RHA (Lbs/y)	Target GFE	Milk production (Lbs/cow per d)	Target GFE
16,000	1.16	55.0	1.25
17,000	1.20	57.5	1.28
18,000	1.24	60.0	1.32
19,000	1.29	62.5	1.35
20,000	1.32	65.0	1.38
21,000	1.36	67.5	1.41
22,000	1.40	70.0	1.44
23,000	1.43	72.5	1.46
24,000	1.47	75.0	1.49
25,000	1.50	77.5	1.51
26,000	1.53	80.0	1.54
27,000	1.56	82.5	1.56
28,000	1.58	85.0	1.58
29,000	1.61	87.5	1.60
30,000	1.63	90.0	1.63
31,000	1.65	92.5	1.64
31,000	1.68	95.0	1.66

**Table 3.** An example of the calculation of the Cow-Jones Index (a.k.a., income over nutrient costs) for February 2008.

<b><i>Animal Inputs</i></b>			
Cow weight (lbs)	1500		
Milk (lbs/d)	65		
Fat (%)	3.6		
Protein (%)	3.0		
Other solids (%)	5.7		
<b><i>Milk component prices input (from FMMO)</i></b>			
Fat (\$/lb)	\$ 1.3010		
Protein (\$/lb)	\$ 4.0180		
Other solids (\$/lb)	\$ 0.0803		
<b><i>Nutrient unit costs inputs (from Sesame)</i></b>			
NE <sub>L</sub> (\$/Mcal)	\$ 0.1330		
Metabolizable protein (\$/lb)	\$ 0.2922		
Effective NDF (\$/lb)	\$ 0.0732		
Non-effective NDF (\$/lb)	\$(0.0906)		
<b><i>Nutrient requirements (from NRC)</i></b>			
NE <sub>L</sub> (Mcal)	31.33		
Metabolizable protein (lbs)	4.64		
Effective NDF (lbs)	10.15		
Non-effective NDF (lbs)	3.38		
<b><i>Milk income</i></b>			
	<b>\$/cow/day</b>		<b>\$/cwt</b>
Fat	\$ 3.04		\$ 4.68
Protein	\$ 7.84		\$ 12.05
Other solids	\$ 0.30		\$ 0.46
<b>TOTAL</b>		\$ 11.18	\$17.20
<b><i>Nutrient Costs</i></b>			
NE <sub>L</sub>	\$ 4.17		6.41
Metabolizable protein	\$ 1.36		2.09
Effective NDF	\$ 0.74		1.14
Non-effective NDF	\$(0.31)		\$(0.47)
<b>TOTAL</b>		\$ 5.96	9.17
<b><i>Income over nutrient costs</i></b>			
		\$ 5.22	8.03
<b>The Cow-Jones Index</b>			
			<b>8.03</b>

**Figure 1.** Example of an output from the *Sesame* program prepared for central California in mid-January 2009.



WDMC -CA

1/19/2009 1:37:35 PM

PricePredictionReliability 40.817

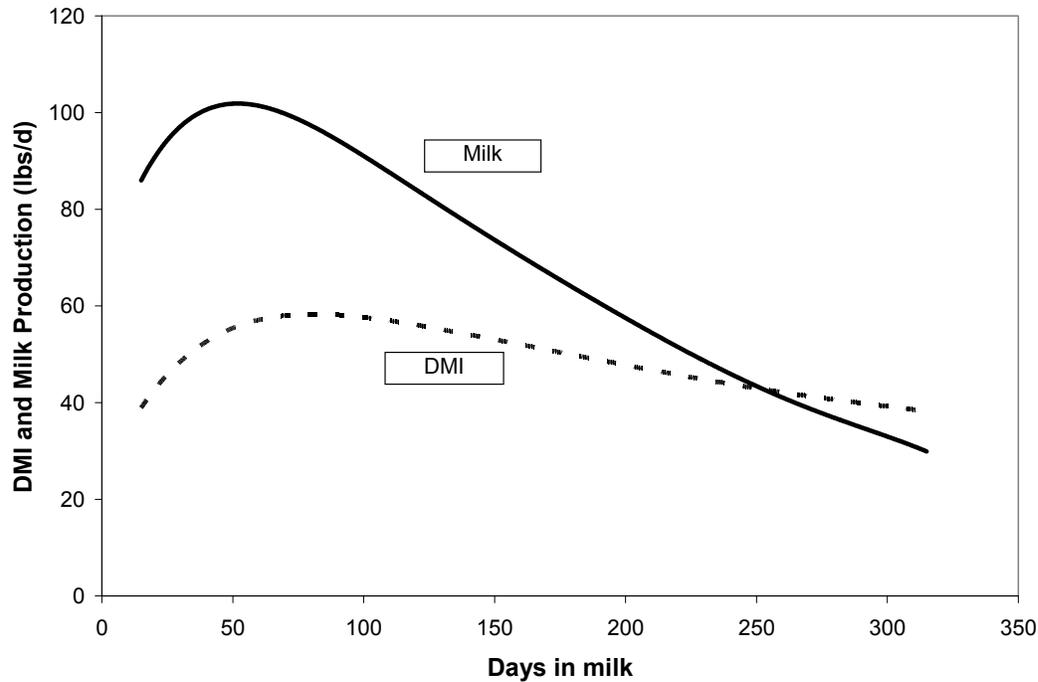
<b>Estimate of Nutrient Unit Costs</b>		
Nutrientname	Estimate	
NEI -3X (2001)	0.063770	**
RDP	0.108014	~
Digestible RUP	0.457194	**
he-NDF	0.033079	~
pe-NDF	0.135773	**

- A blank means that the nutrient unit cost is likely equal to zero
- ~ means that the nutrient unit cost may be close to zero
- \* means that the nutrient unit cost is unlikely to be equal to zero
- \*\* means that the nutrient unit cost is most likely not equal to zero

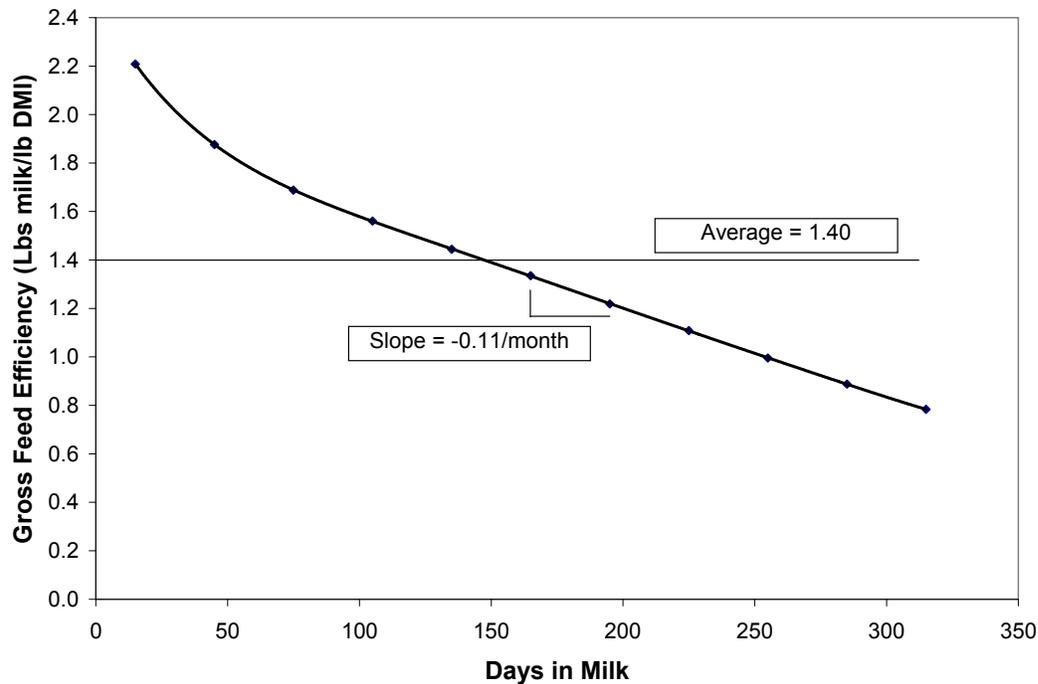
<b>Calibration set</b>								
Name	Actual [T]	Predicted [T]	Lowerlimit	Upperlimit	Corrected	75.0% CI	75.0% CI	
Alfalfa Hay #1 - 25.0 CP, 3	225.000	238.434	220.971	255.898	263.071	245.607	280.535	
Alfalfa Hay #2 - 20.0 CP, 4	200.000	219.331	200.843	237.818	230.208	211.721	248.696	
Almond Hulls	128.000	150.957	135.022	166.892	-	-	-	
Barley Grain, rolled	210.000	163.317	153.018	173.617	-	-	-	
Blood Meal, ring dried	700.000	651.849	618.124	685.574	-	-	-	
Canola Meal, mech. extract	330.000	253.312	237.400	269.225	-	-	-	
Corn Germ Meal	200.000	233.617	218.724	248.510	-	-	-	
Corn Grain, steam flaked	190.000	162.185	149.287	175.083	-	-	-	
Corn Silage - Central Valle	55.000	65.236	59.792	70.681	65.236	59.792	70.681	
Cotton Seed Hulls	220.000	171.928	141.401	202.455	-	-	-	
Cotton Seed Meal, 41% C	310.000	338.147	325.166	351.128	-	-	-	
Cotton Seed, Whole w/lint	317.000	294.836	269.280	320.393	-	-	-	
Distillers Dried Grains w S	180.000	257.064	241.035	273.094	-	-	-	
Feathers Hydrolyzed Meal	500.000	513.857	491.431	536.283	-	-	-	
Gluten Feed, dry	210.000	215.917	204.804	227.030	-	-	-	
Gluten Meal, dry	490.000	515.814	490.959	540.669	-	-	-	
Hominy	180.000	154.761	143.546	165.976	-	-	-	
Meat Meal, rendered	330.000	368.796	347.341	390.251	-	-	-	
Molasses, Sugarcane	175.000	88.474	78.426	98.521	-	-	-	
Pima Cottonseed, craked	282.000	309.139	286.290	331.988	-	-	-	
Rice Bran	140.000	178.896	164.968	192.824	-	-	-	
Soybean Hulls	185.000	166.312	139.601	193.023	-	-	-	
Soybean Meal, expellers	405.000	416.517	398.999	434.035	-	-	-	
Soybean Meal, solvent 44	360.000	318.719	297.028	340.409	-	-	-	
Soybean Meal, solvent, 46	370.000	358.435	339.372	377.497	-	-	-	
Tallow	250.000	261.742	220.838	302.645	-	-	-	
Wheat Bran	157.000	157.908	139.498	176.319	-	-	-	
Wheat Middlings	160.000	169.324	153.109	185.538	-	-	-	

<b>Appraisal set</b>			
Name	Actual [T]	Predicted [T]	Corrected
Fish Anchovy Meal, mech	920.000	483.224	-

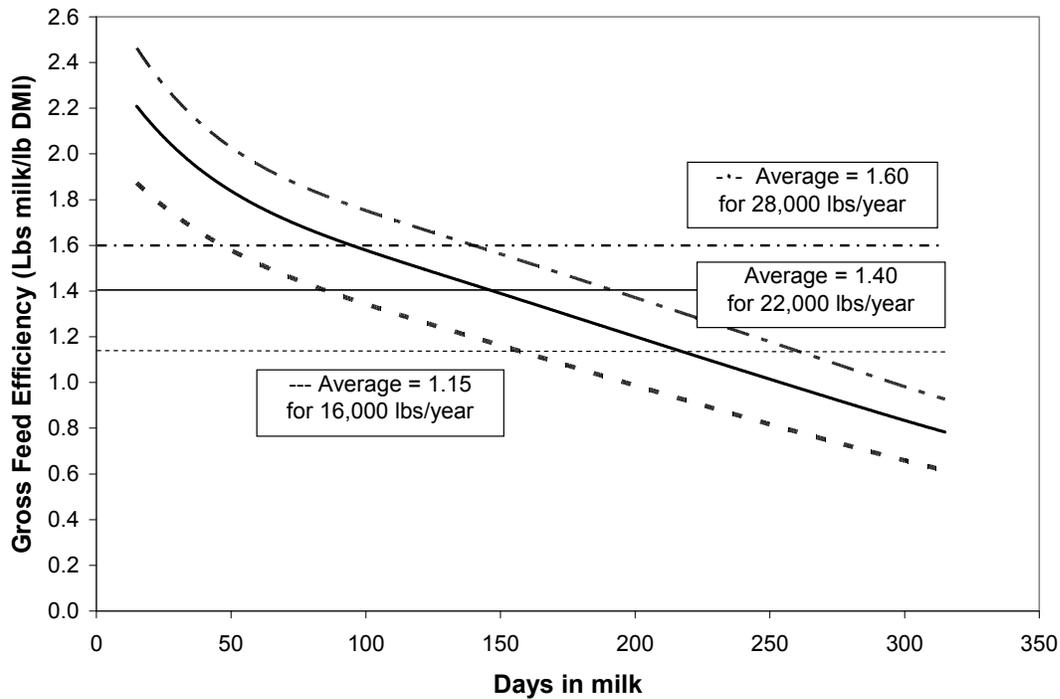
Sesame 3.03: Regression results (Sesame [Administrator])



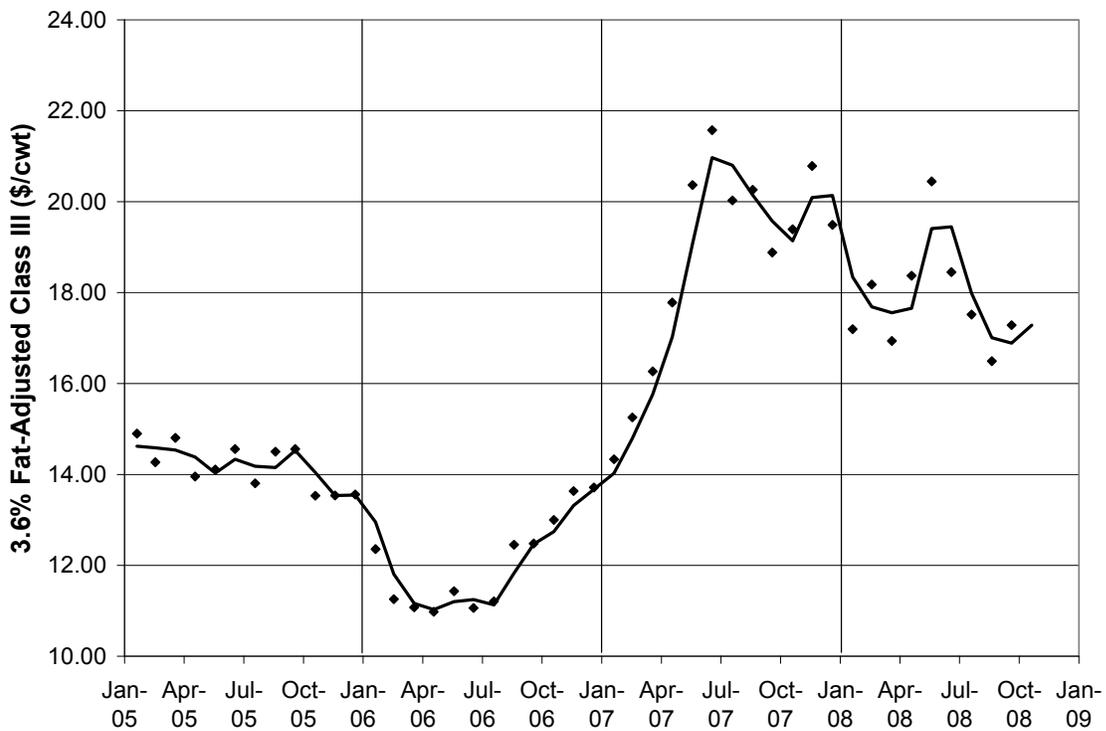
**Figure 2a.** Daily dry matter intake (DMI) and milk production of a third parity cow producing 22,000 lbs of milk in 330 days. Lactation curve was calculated using a gamma function (Kellogg et al., 1977); DMI was estimated according to NRC (2001).



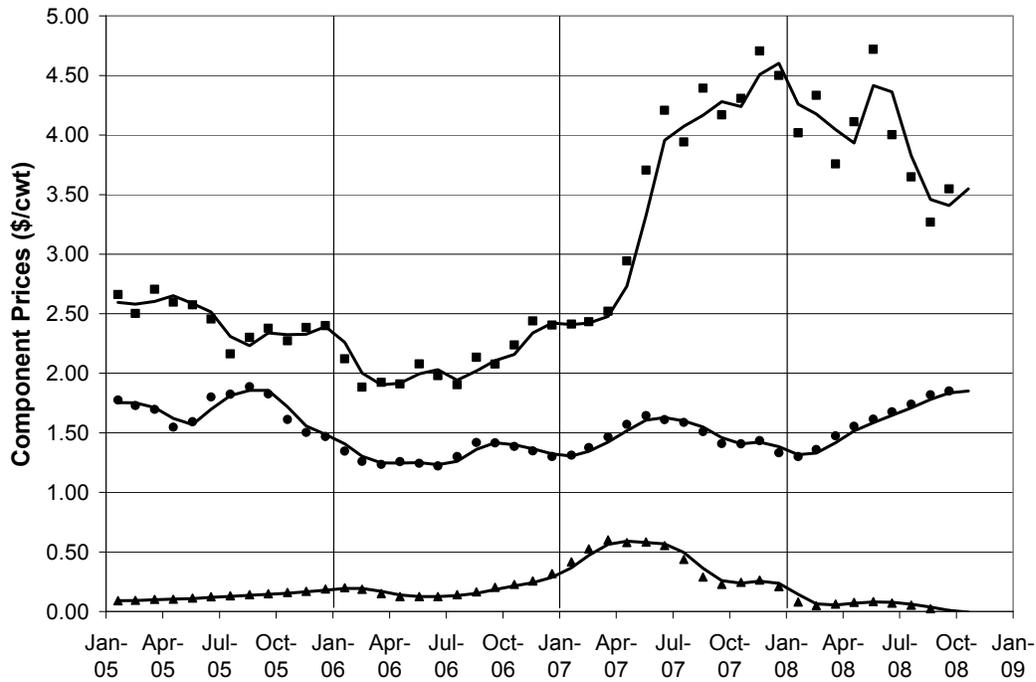
**Figure 2b.** Instantaneous gross feed efficiency across a lactation cycle for a cow with production and intake characteristics reported in Figure 1a.



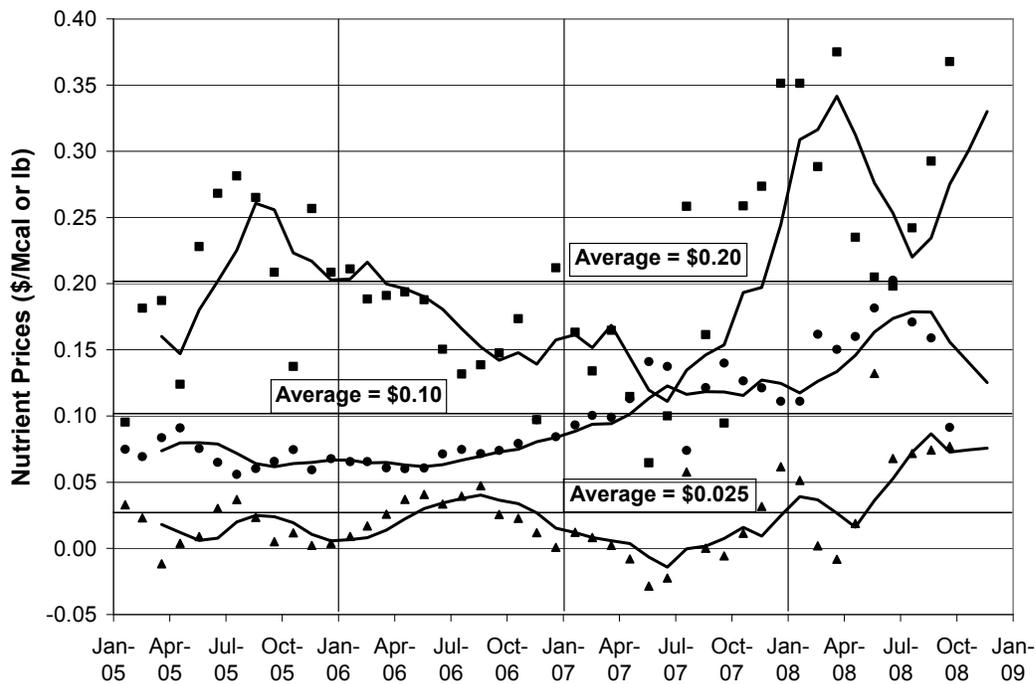
**Figure 3.** Comparative gross feed efficiency across a lactation cycle for a cow producing 16,000 (---), 22,000 (—) and 28,000 (-·-) lbs of milk in a 330 d lactation.



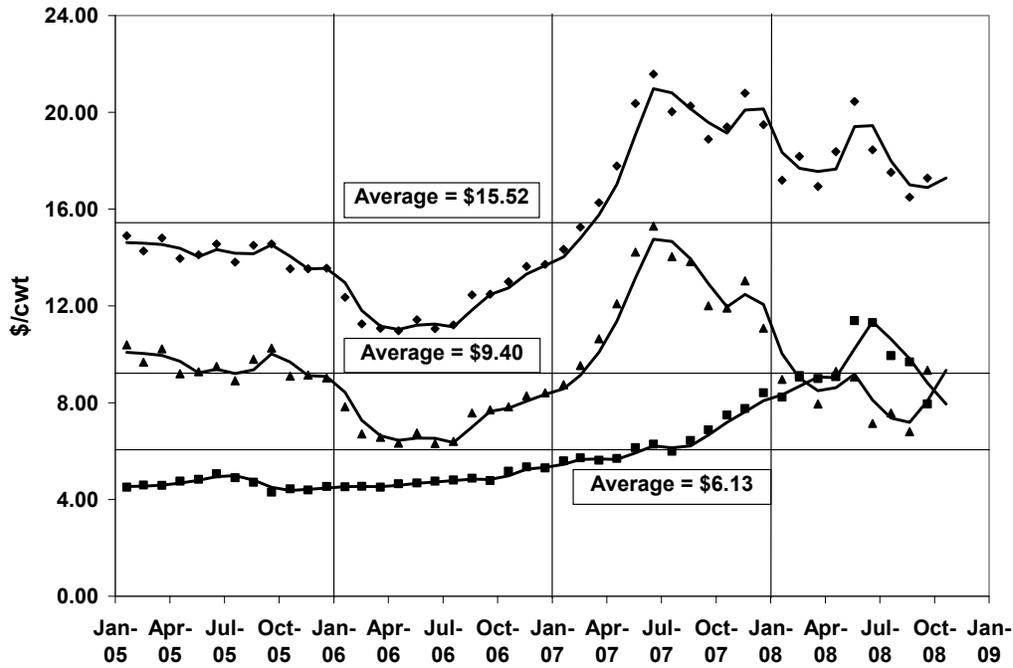
**Figure 4.** Uniform milk prices in Federal Orders from January 2005 through October 2008.



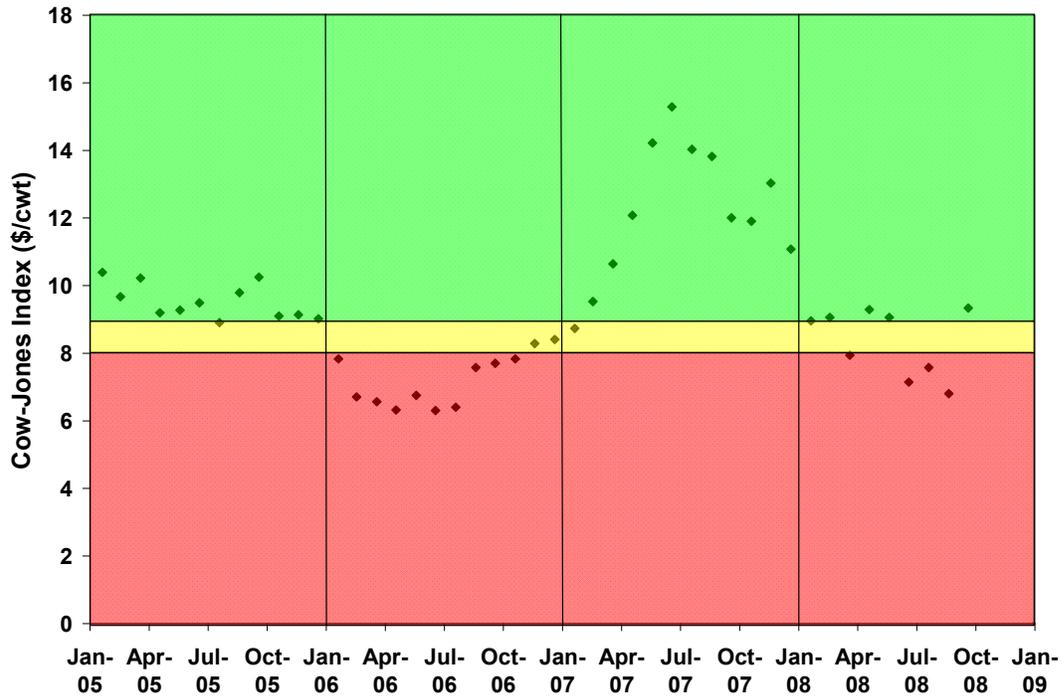
**Figure 5.** Milk component prices in Federal Orders from January 2005 through October 2008; ■ = protein (\$/lb), ● = fat (\$/lb), and ▲ = other solids (\$/lb).



**Figure 6.** Costs of nutrients between January 2005 and October 2008; ■ = cost of metabolizable protein (\$/lb), ● = cost of net energy for lactation (\$/Mcal), ▲ = cost of effective NDF (\$/lb). Results are from *Sesame*, using central OH prices.



**Figure 7.** Milk revenues (■), nutrient costs (●), and income-over-nutrient-costs (▲ – the Cow-Jones Index) between January 2005 and October 2008.



**Figure 8.** The Cow-Jones Index between January 2005 and October 2008. The average dairy producer loses money when the index falls below \$8.00/cwt, makes money when it exceeds \$9.00/cwt, and experiences variable and marginal profitability when the index falls between \$8.00 and \$9.00/cwt.

# Solving Bad Water Problems for Thirsty Cows

David K. Beede, PhD  
Department of Animal Science  
2265K Anthony Hall  
Michigan State University  
East Lansing, MI 48824-1225  
Tel: 517-432-5400  
Fax: 517-432-0147  
Email: [beede@msu.edu](mailto:beede@msu.edu)

## Take Home Messages

- Abundant, high quality drinking water is the most important essential nutrient for your dairy cows. If water nutrition (quality and/or quantity) is an issue, you and your cows have a big problem!
- Based on analyses of over 200 ‘suspect’ drinking water samples from across the U.S. in the last 10 years the most common water quality problems are high iron and high anion contents that can affect cow health and performance.
- The only way to know for sure if drinking water in your dairy has excess concentrations of iron (greater than 0.3 ppm) or anions (sulfate + chloride; greater than 1,000 ppm) is to have water samples analyzed periodically at a reputable laboratory.
- Procedures for sampling and a few certified laboratories are listed at: <http://www.msu.edu/~beede/>; click on Extension and then “Taking a Water Sample”.
- Water treatment methods are available to remove iron, sulfate and chloride: chlorination with filtration; ion exchange; ozonation; reverse osmosis; and/or, an oxidizing filter.
- If water quality is not an issue, the most common water nutrition problem in most dairies is not providing enough watering stations, enough space at watering stations, and thus, enough uninhibited drinking opportunities for each cow during her normal daily routine where she lives and is milked. In recent years, lack of adequate water supply is often related to over-stocking in group housing areas, whether free stalls barns or loose housing.

## Introduction

This paper focuses specifically on the most common bad water problems and potential solutions encountered in the last several years. For a more comprehensive review of published information on water nutrition for dairy cattle readers are referred to McFarland (1998), NRC (2001), and Brouk et al. (2001), and Beede (2006).

## Bad Water – Primary Quality Problems

Based on analyses of over 200 ‘suspect’ drinking water samples from dairies across the U.S. in the last 10 years the most common potential water quality problems are high iron and high anion (sulfate + chloride) contents that can affect cow health and performance. The only way to know for sure if drinking water in your dairy has excess concentrations of iron or anions (sulfate + chloride) is to have water samples analyzed periodically by a reputable laboratory.

**Iron.** Excess iron in drinking water can cause iron toxicity and is a major problem in some dairies across the country. In this time of high input costs, excess iron in drinking water and subsequent poor cow performance can be the business-breaker. Fortunately, excess iron in drinking water is relatively easy to measure with a standard laboratory analysis and then corrective action can then be taken.

The recommended maximum tolerable concentration of iron in drinking water is 0.3 ppm (parts per million; or, milligrams/liter). Concentrations in excess of this can be detrimental to normal health and lactational performance of dairy cows, and a significant health risk for humans consuming the water. A cow producing 100 pounds of milk requires about 35 milligrams of absorbed iron daily, commonly supplied in her ration (NRC, 2001). However, if she consumes drinking water with 0.3 ppm iron (versus no iron in water) her total absorbable iron intake doubles. If the drinking water contains 0.6 ppm iron, then total absorbable iron intake is about three-times the daily requirement.

Typically, there is plenty of total iron in rations to meet the cow's daily absorbed iron requirement, even though dietary iron is poorly absorbed from the digestive tract; only about 10 percent of iron from rations is absorbable. The common chemical form in feed ingredients is ferric iron,  $Fe^{+3}$ , which is quite insoluble. In contrast, the iron in drinking water is highly soluble and very absorbable (ferrous iron,  $Fe^{+2}$ ), so major problems can result from excess iron in drinking water which is readily absorbed into the body.

Excess absorbed iron from drinking water can lead to cellular oxidative stress and inhibit copper and zinc absorption. Oxidative stress results in damage to cell membranes and disrupts normal physiological functions and biochemical reactions. It is suspected that consequences of excess absorbed iron and heightened oxidative stress are magnified in transition and fresh cows. These consequences include compromised immune function, increased fresh cow mastitis and metritis (excess ferrous iron in the body enhances the potential for bacterial infections), greater incidence of retained fetal membranes, diarrhea, depressed feed intake, and reduced growth and milk production.

Experience in commercial dairies the last several years indicates rather remarkable improvements in lactational performance and cow health when excess iron is removed from drinking water (treatment options to remove excess iron are addressed in a later section of this paper).

High iron in drinking water also may reduce water intake, apparently because ferrous iron is unpalatable (not acceptable). Reduced water intake directly reduces feed intake and milk production (Beede, 2006). Also, the dark reddish-brown slime formed by iron-loving bacteria in water troughs may affect water intake and even the rate flow and volume through pipes. To my knowledge, it is not known if these iron-loving microorganisms directly affect the digestion, metabolism, or physiology of cows. However, field experience suggests that treating drinking water with high iron content (such as treating with a solution of 35% hydrogen peroxide at a rate of about 8 ounces per 1000 gallons of water) will eliminate these microbes and improve milk yield and health of cows. In the time immediately after treatment with hydrogen peroxide it may be necessary to remove filters, open valves, and even open (e.g., cut) the water pipes at the terminal end of flow to purge the slime that has been loosened from the plumbing. Hydrogen peroxide treatment at this low dosing level can be continued if felt necessary.

If high-iron (greater than or equal to 0.3 ppm) drinking water is present, an alternative water source with lower iron concentration should be found. Or, a method to remove the iron from water before consumption by cattle or humans should be used. Water treatment methods to remove iron are addressed below under the section on 'Water-treatment Options'.

**Sulfate + Chlorine.** Typically, if the total dissolved solids (TDS) concentration of a water sample is high (greater than 500 ppm) the first constituents to focus on are sulfate and chloride. Sulfate and chloride are biologically active anions (negatively charged ions) that if in excess potentially can negatively influence a cow's digestion, electrolyte balance, acid-base status and lactational performance. If the sum of the concentrations of sulfate plus chloride is greater than 1,000 ppm a thorough evaluation should be done to determine whether or not the anions are affecting cow health and performance.

Based on field experience, excessively high concentrations of sulfate plus chloride (greater than 1,000 ppm) in drinking water can reduce water consumption. However, much of the early research addressing effects of sulfate and chloride concentrations in drinking water evaluated much higher concentrations than are typically found, even from the deep wells in the western U.S. states (Beede, 2006). In summary, the maximum tolerable concentrations of sulfate found in experimentation ranged from about 3,500 ppm, causing significant reduction in water intake, weight gain, and feed intake of beef heifers, to as low as about 1,450 ppm sulfate when beef heifers still gained some weight, but less than heifers drinking low-sulfate water. In that study, heifers discriminated against the water containing 1,450 ppm sulfate, and outright rejected water with 2,800 ppm sulfate. These results suggest that the tolerance threshold for sulfate may be around 1,450 ppm, at least for growing heifers. More recent research from the University of British Columbia showed that drinking water was unpalatable to beef heifers and steers if it contained 3,200 or 4,700 ppm sulfate from sodium or magnesium sulfate salts. Animals offered high-sulfate water also changed their pattern of consumption, drinking more frequently at night compared with animals offered low-sulfate water that drank more during the day. Also, when the poorer quality, high-sulfate water was offered, animals showed more aggressive behavior towards each other when trying to drink. However, 1,500 ppm sulfate did not reduce water consumption (Zimmerman et al., 2002).

Similar controlled experimentation is not available for lactating dairy cows assessing the maximum tolerable concentrations of sulfate and chloride that affect water intake and lactational performance. However, field experience suggests that the tolerable concentration is likely well below 1,450 ppm. Based on available research reports and personal field experience, when sulfate plus chloride concentrations in water exceed 1,000 ppm careful evaluation of animal performance, including measurement of water intake, should be done. A proposed approach for evaluation is listed subsequently. High-sulfate (e.g., 1,200 ppm) drinking water reduced performance of transition-fresh dairy cows by causing reduced feed intake and milk yield, and increased incidences of retained fetal membranes and abomasal displacement (Beede, personal observation). When reverse osmosis treatment was instituted and low-sulfate water (less than 15 ppm) was provided, fresh cow problems declined dramatically. Because, chloride also is a biologically active anion, a useful rule of thumb in assessing water quality is to check whether or not the sulfate plus chloride concentrations exceed 1,000 ppm. If they do, careful evaluation and testing are highly recommended. Water treatment methods to remove excess sulfate and chloride are addressed under the section on 'Water-treatment Options' below.

**Hydrogen Sulfide.** In reporting of water analysis, sulfur typically is differentiated from sulfate. Sulfur present as hydrogen sulfide (H<sub>2</sub>S), imparting the rotten egg smell, is believed to affect water intake. Water intake increased at least in the short-term when water without the smell was offered (Beede, personal observation). However, it is not known what concentration of hydrogen sulfide or what intensity of smell reduces normal water intake of cattle; or, if they adapt to the smell and have normal water intake rates if no other water is available.

## Water-treatment Options

If based on water analysis, excess iron, sulfate, or chloride is a concern for cow health and performance, the next question is --- “What can and should be done about it?” A different water source may be the best long-term solution (such as a new well or perhaps a municipal water source). To treat water to remove constituents in excess is the other option. This has been accomplished successfully and economically in some dairy farms (Beede, personal observations). However, it may not be cost-effective in every case. Careful evaluation of the magnitude of the problem, how much potential benefit can be expected from removing unwanted constituents, and at what cost are key considerations. Most dairy farms use relatively large volumes of water and treatment systems must be sized accordingly. Table 1 provides questions that should be addressed if considering a water treatment system to remove unwanted constituents.

Table 2 provides a general guide for major treatment methods to remove excess iron, sulfate and chloride, and some other unwanted constituents (adapted from [www.midwestlabs.com](http://www.midwestlabs.com)). This table is meant to provide an initial guide for treatment methods; then a user can address specific water quality problems with water treatment companies in the local region. It is highly recommended that dairy producers and consultants compare effectiveness, life expectancy, volume capacity, maintenance time, and initial capital and maintenance costs of each method with several regional commercial companies before making any significant investments (Table 1).

### Removal of Iron.

Excess water-soluble iron can be removed by one or a combination of five methods (Table 2): 1) chlorination with filtration; 2) a cation-anion exchange system, especially when iron concentrations are less than 1.0 ppm; 3) ozonation; 4) reverse osmosis; and/or, 5) an oxidizing filter.

**Chlorination** can remove dissolved iron, manganese, and hydrogen sulfide if followed by mechanical or activated carbon filtration. Chlorine is pumped directly into the water in proportion to water flow and it may have some residual effects in the system. If the chlorination system is not properly operated, it can be expensive and potentially hazardous if chlorine byproducts are allowed to escape. In typical systems the chlorine content of the treated water should not be high enough to cause problems for cattle. However, cases of over-chlorination have been noted where the chlorine concentration was high enough in water to reduce milk fat percentage dramatically (presumably by affecting ruminal fermentation); the situation quickly reversed when chlorination was discontinued (Beede, personal observation). In another case, high concentrations of chlorine (1,000 to 1,500 ppm) resulted in a dairy’s watering system when the city cleaned its system; in this case water intake and lactational performance were reduced. In other situations, addition of chlorine tablets in the water tanks, causing spikes in chlorine content mainly to control algae growth, apparently affected water consumption, even with the slow-release tablets. Alternative methods (cleansers, brush and thorough rinsing) are recommended for routine water trough cleaning.

**Filtration.** Use of mechanical filters is recommended with chlorination to remove soluble and insoluble iron and manganese, sand, silt and clay (turbidity) and to reduce plugging or wear on equipment. Activated carbon filters use carbon granules to adsorb free chlorine, and some compounds associated with coloration, odor and off-taste of water; mercury; some pesticides; radon gas; and volatile organic compounds. Depending upon the amount of water treated, the filters may have to be replaced frequently and regularly. Infrequent filter maintenance may result in bacterial growth on the filter and reduced effectiveness.

**Cation - Anion Exchange.** An ion exchange system can be used to remove iron and manganese at relatively low concentrations (such as less than 1 ppm or less); a common system is known as the ‘iron curtain’ although other ion exchange systems are available commercially for various applications. Consultation with local vendors will help determine the most cost-effective and reliable systems to treat large volumes of water used in most dairies.

**Ozonation** can be used to remove solubilized iron and manganese, if the water is subsequently passed through mechanical or activated carbon filtration. Ozonation also destroys microorganisms and there are no residual effects of the ozone (a potent oxidizer of organic compounds) on the environment or treated water. This method also can be used to remove color, off-taste, odors, and hydrogen sulfide.

**Reverse osmosis** technology has been used successfully to remove iron, sulfate, chloride and other unwanted constituents (Beede, personal observation). Basically impurities are filtered from water using membranes. The initial costs are relatively high with high membrane replacement costs. High volume through-put capacity is needed in most dairies because the process is relatively slow. The systems take routine and consistent maintenance. They also are somewhat wasteful of water and the high-solutes filtrate must be disposed of. A wide variety of constituents can be removed: most inorganic substances, nitrate, some pesticides, odors, off-taste compounds, radium, salts, and some volatile organic compounds.

**Oxidizing filters** remove undissolved and dissolved iron, and manganese by filtering and chemical (oxidizing) reactions; hydrogen sulfide also can be removed in this manner.

#### **Removal of sulfate and chloride (anions)**

Two approaches to remove excess sulfate and chloride are: 1) reverse osmosis, as described above, is most common; and possibly, 2) distillation. Otherwise, an alternate water source must be found if it is clear that high sulfate and/or chloride are affecting negatively animal performance and profitability. *Distillation* can purify water that contains any assortment of solids such as inorganic compounds, nitrate, odor, off-taste, some pesticides, radium, salt, and volatile organic chemicals that have high boiling points. However, the process is slow, expensive (high energy cost), and for a dairy farm, large volume-capacity may be needed to provide sufficient distilled water, depending upon herd size.

Whatever the most appropriate treatment method to remove iron, sulfate and/or chloride from drinking water, here are some recommendations on how to proceed to a solution if one suspects high anti-quality constituents in drinking water.

1. Take a water sample(s). For guidelines on how to take drinking water samples and standard water analysis refer to: <http://www.msu.edu/~beede/>, click on Extension and then “Taking a Water Sample”.
2. Have a standard laboratory analysis for “livestock water” done by a certified laboratory.
3. If the laboratory reports iron concentrations greater than 0.3 ppm and/or either sulfate or chloride concentrations greater than 500 ppm, take two more samples and send each to a different certified laboratory for analyses. This may seem like over-kill at the time, but water treatment systems are a major investment, so it is important to know for sure that concentrations are in excess.
4. When collecting samples for laboratory testing, take and label two more samples to save as back-ups and a historical record.
5. If one or more of these constituents is in excess, contact at least two or three water treatment companies and ask about their treatment methods, and if and how they remove iron, sulfate, and/or

chloride from water. Local or regional companies typically are best to ensure good customer service and maintenance after installation. Also, refer to Table 1 for guidelines on fact-finding about water treatment options.

6. After a treatment system is installed, take treated water samples at least every month, label, and tightly seal them (to stop possible evaporation), and store in a cool place for historical purposes. At least every third month send a sample to a certified laboratory for a standard “livestock” analysis, including iron, sulfate and chloride. Is the water-treatment system removing the anti-quality constituents as guaranteed?

### **H<sub>2</sub>O<sub>dot</sub> con: Water-related Pseudoscience Fantasy and Quackery**

There is a plethora of people and companies willing to sell water treatment systems of every size, shape, and treatment method, whether water treatment is needed or not, and whether their method actually works or not. For those wondering about the effectiveness of one or many of the supposed treatment methods an interesting and helpful Web Site is called “*H<sub>2</sub>O<sub>dot</sub> con: Water-related Pseudoscience Fantasy and Quackery*” < <http://www.chem1.com/CQ/> >. This site was developed by Dr. Stephen Lower, retired faculty member in the Department of Chemistry at Simon Fraser University, Burnaby, Vancouver, Canada. Dr. Lower developed and writes at the Site to address and help consumers sort out which of the many alleged water treatment methods actually have scientific merit and which ones are most likely quackery. It seems that most water treatment methods offered to solve purported bad water problems in commercial dairy farms were (are) first available and/or sold to homeowners and consumers. To quote from the Web Site about Junk Science in the Market Place, “*Magnets and “catalysts” for softening water, magnetic laundry balls, waters that are “oxygenated”, “clustered”, “unclustered” or “vitalized” (purporting to improve cellular hydration, remove toxins, and repair DNA), high zeta potential colloids and vortex-treated waters to raise you energy levels, halt or reverse ageing and remove geopathic stress -- all of these wonders and more are being aggressively marketed via the Internet, radio infomercials, seminars, and by various purveyors of new-age nonsense. The hucksters who promote these largely worthless products weave a web of pseudoscientific hype guaranteed to dazzle and confuse the large segment of the public whose limited understanding of science makes them especially vulnerable to this kind of exploitation.*

*The purpose of this site is to examine the credibility of these claims from the standpoint of our present-day knowledge of science. The latter, of course, is always evolving and is never complete, but it makes an excellent “B.S. filter” that is almost always reliable. It is hoped that the information presented here [at the Web Site] will help consumers make more informed decisions before offering up their credit cards to those in the business of flogging pseudoscience.”*

### **In Conclusion**

For dairy producers and their advisers an appropriate closing message on water treatment methods would be, “*Show me the science and the proof of improved cow health and performance before I show you five or six figures in George Washington’s finest dollars.*”

## Suggested References

Beede, D. K. 2006. Evaluation of water quality and nutrition for dairy cattle. Proc. High Plains Dairy Conf., Albuquerque, NM.

Beede, D. K. 2009. Procedures for sampling and a few certified laboratories are listed at: < <http://www.msu.edu/~beede/> >, click on Extension and then “Taking a Water Sample”.

Brouk, M. J., J. P. Horner, III, and J. F. Smith. 2001. Water trough placement key to managing summer heat stress at: < [http://www.oznet.ksu.edu//dp\\_ansi/dairylin.htm](http://www.oznet.ksu.edu//dp_ansi/dairylin.htm) >.

Lower, S. 2009. Water DotConWeb Site (H<sub>2</sub>O<sub>dot</sub> con). Water-related pseudoscience fantasy and quackery at: < <http://www..chem1.com/CQ/> >. Dr. Stephen Lower, retired faculty member from the Department of Chemistry at Simon Fraser University, Burnaby, Vancouver, Canada, writes and maintains this Web Site.

McFarland, D. F. 1998. Watering dairy cattle. Proc. NRAES Dairy Feeding Systems Management, Components, and Nutrients Conference, Camp Hill, PA.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. Natl. Acad. Sci., Washington, DC.

Zimmerman, A., D. Veira, M. von Keyserlingk, D. Weary, and D. Fraser. 2002. Water quality affects cattle drinking behavior and consumption. The University of British Columbia, Dairy Education and Research Centre, Research Report. Vol. 2, No. 9.

Other references about water nutrition of dairy cattle, are available at: < <http://www.msu.edu/~beede/> > by clicking on “Extension”, and then “Water Ref”.

**Table 1.** Questions to ask sales and service representatives from prospective water-treatment companies.

---

- 1.** Do you know how much water this particular dairy uses? Obviously, the company representatives will not know this, but you've got to know the answer to this question! Most dairies use a lot of water; often much more than companies are accustomed to treating at a single location. What is the treatment rate (volume/time)? Can their system supply enough water for all functions on the dairy simultaneously during peak usage (e.g., during milking, parlor clean-up and when cows are drinking)? Will a sizable investment in large long-term storage of the treated water be necessary to ensure that you have ample supply during peak usages?
  - 2.** Does each company guarantee that their system will remove iron, sulfate or chloride as needed based on the water analyses? Are they willing to provide a written guarantee that their system will remove these unwanted constituents throughout the specified life of the treatment system?
  - 3.** How long will the systems last and how much maintenance is required? Who does the maintenance? Do they have "service-after-the-sale" and what does that entail? Do they have or can they provide a maintenance contract?
  - 4.** Which other anti-quality factors (besides iron, sulfate, and/or chloride) do their water treatment systems remove? There may be none. But, there also may be additional benefits to one treatment system over another if other constituents are in excess in water samples.
  - 5.** What chemicals (e.g., other mineral elements) does their particular treatment method add to the water and what will be their concentrations? There may be nothing added. But, in other cases something may be added, such as significant chlorine during chlorination. It must be determined if the additions are of any consequence, bad or good.
  - 6.** What do the systems cost — installation, and monthly maintenance and operating costs?
-

**Table 2.** General guide for treatment methods to remove unwanted constituents from drinking water (adapted from www.midwestlabs.com).

Constituent	Treatment Methods <sup>a</sup>									
	ACI	AS	C	D	C-A	MF	RO	UR	O	OF
Chlorine	X <sup>b</sup>									
Coliform bacteria, other microorganisms			X					X	X	
Color	X		X		X				X	
Hydrogen sulfide		X	X <sup>c</sup>						X <sup>c</sup>	X
Inorganics [e.g., some macromineral elements and heavy metals (e.g., mercury, arsenic, cadmium, barium)]	X <sup>d</sup>			X	X <sup>e</sup>		X			
Iron/ manganese –dissolved			X <sup>e</sup>		X <sup>f</sup>				X <sup>e</sup>	X
Iron/ manganese – insoluble						X				X
Nitrate				X	X <sup>g</sup>		X			
Odor and off-taste	X	X	X	X	X		X		X	
Some pesticides	X <sup>h</sup>						X <sup>h</sup>			
Radium				X	X		X			
Radon gas	X	X								
Salt				X			X			
Sand, silt, clay (turbidity)						X				
Volatile organic chemicals	X	X		X <sup>i</sup>			X			
Water Hardness					X					

<sup>a</sup> ACF = activated carbon filter; AS = air stripping; C = chlorination; D = distillation; C-A E = cation or anion exchange; MF = mechanical filtration; RO = reverse osmosis; UR = ultraviolet radiation; O = ozonation; and, OF = oxidizing filters.

<sup>b</sup> Within the table “X” indicates method that can be used to remove part or all of the constituent present.

<sup>c</sup> When followed by mechanical filtration or an activated carbon filter.

<sup>d</sup> Mercury only.

<sup>e</sup> Barium only.

<sup>f</sup> When present in low concentrations.

<sup>g</sup> Anion exchange units will remove nitrate; but, cation exchange units will not.

<sup>h</sup> For information on ways to treat water for specific pesticides, obtain local pesticide health advisory summaries.

<sup>i</sup> Works for volatile organic chemicals with high boiling points.



# Don't Let Shrink Kill You with High Feed Prices

Dr. Micheal Brouk  
Associate Professor, Extension Specialist, Dairy  
Department of Animal Sciences and Industry  
134 Call Hall, Kansas State University, Manhattan, KS 66506-1600  
Tel 785-532-1207; fax 785-532-5681  
[mbrouk@ksu.edu](mailto:mbrouk@ksu.edu)

## Take Home Message

- Many factors result in feed waste or shrink
- Shrink may represent 15-20% of total feed cost
- Wet and expensive ingredients represent the greatest concern
- Low milk price and relative high feed prices increases the importance of reducing shrink
- Lowering feed shrink is an economic opportunity for nearly all dairies

## Introduction

Feed shrink is a major negative economic factor on dairy farms. On most dairies, feed cost will represent the largest single cost center. As feed prices have increased, awareness of this issue has increased. Feed shrink could simply be defined as the amount of feed that is delivered or raised on the farm that is not consumed by the cattle. Maybe the most important technical advancement in this area has been the adoption of on-farm scales, both for incoming trucks and on feed mixing equipment. In the last 10 years, there have been significant advances in computer software to help producers track feed mixing operations and changes in inventory. One can not manage what is not measured and the combination of scales and software has given us wonderful tools to take greater control of feed shrink on dairy farms. Feed shrink is caused by many factors including; delivery weight errors, wind, birds, rodents, tires and tracked feed, cattle tossing feed, silage bunker losses, feed refusals, bunk heating and spoilage, moisture losses, mixing errors, scale accuracy and water damage. These losses may represent 5-30% of the feed purchased by the farm. Reducing feed cost will be a primary concern for producers during times of depressed milk prices and reducing feed loss or shrink is an important part of reducing overall feed cost.

## Delivery Weight Errors

Are you getting what you paid for? The use of on-farm scales for every bulk product delivered to the farm as well as milked shipped has greatly increased. While the cost of a semi-truck scale is significant, it is very beneficial to the dairy. As dairies increase in size, the cost of the scale is greatly diluted and becomes a minor investment in the total operation, but one that has a great potential for profit. For example, if a 2,000 cow dairy feeds 4 pounds of soybean meal per cow each day, a semi-truck load would be needed each week. If the loads were only short 100 pounds each week, it would amount to 2.5 tons on the year or at today's prices, about \$1,000. When buying forages, this may be more important. Estimating the weights of trucks when chopping silage will guarantee that someone loses, either the grower or the buyer. It would not be unusual for a 2,000 cow dairy to purchase 800-900 loads of corn silage in a single year. Thus, even a 100 pound per

load difference in weight could represent 45 tons of material. The situation is even worse under muddy field conditions. If you are utilizing a tare weight on a clean truck for a truck that has become caked with mud, you may be paying for 500 pounds of mud each time the truck crosses the scale. Thus, checking tare weights for each load or many times during the day is very important. Also, consider if the driver was on or off the truck and the amount of fuel present when the tare weight is taken. If you do not have scales on your farm, consider utilizing scales at local business to ensure that you are getting all that you are paying for.

### **Wind**

How much of your feed becomes dust in the wind? In some areas, wind is a daily threat to controlling feed cost. Dry ingredients with a small particle size and low density are the most affected by wind losses. Soybean hulls, soybean meal, and dried corn gluten feed would be some examples. These are easily carried away by the wind. Commodity sheds which are designed to allow trucks to dump on the concrete apron outside the facility and then a loader is utilized to move the feed back into the shed result in significant losses on windy days. Some on-farm records indicate that losses of soybean meal in a commodity shed are 8-9 percent. If you are paying \$380/ton for soybean meal, the real cost is about \$414/ton, or at 4 pound daily feeding rate, daily feed cost just increased by 6.8 cents per cow. In areas where wind is a factor, consider wind direction when planning facilities. If you are utilizing a dry, low density product, consider pelleting or mixing some fat or other ingredients with the product to increase density and reduce the effect of wind. The use of windbreaks around commodity sheds may also be helpful in reducing feed losses.

### **Birds**

How many birds did you feed today? Starlings may create a significant negative impact on feed cost. Starling can consume up to 50% of their body weight in grain each day. You can be thankful that your cows don't consume 50% of their body weight each day, but, a flock of several thousand birds represents a significant threat to your income. In addition, fecal contamination may pose a disease threat to pregnant animals and calves. Fecal contamination may also reduce feed intake. Daily feed consumption is estimated at 0.0625 pounds per starling. If there are 20,000 birds present and 80% are utilizing the feed bunks, this represent 1,000 pounds of feed each day or 7,000 pounds per week. It is important to keep in mind that the feeding birds consume only concentrate. If concentrate cost is \$0.15/pound, the cost of feeding the birds is \$150.00 per day or \$1,050 per week. If the dairy is feeding 2,000 lactating cows, this represents 7.5 cents/cow each day, or increases feed cost per cwt of milk by 10 cents if the herd is producing 75 pounds of milk each day.

Another factor to consider is the impact of birds upon the nutrients contained in the ration. The forage is left for the cattle resulting in a diet that is unbalanced. In the example above, 0.5 lb of concentrate per cow is removed from the ration. This could represent 1.5 to 2 pounds of daily milk per cow. If there are further reductions in feed intake due to fecal contamination, the potential milk loss is even greater. The loss in milk production is likely greater than the loss of feed.

Bird control is usually needed 2-4 months each year. Facility design can greatly reduce the losses due to birds. Controlled environment barns, tunnel or cross-ventilated barns reduce bird losses in the feed bunk to near zero, however, potential losses may still occur in commodity storage areas. In dry lots and naturally ventilated freestall barns, birds are going to be an issue. Exclusions methods in

freestall barns may help, but the drive alleys usually have openings on both ends of the barn providing an entrance into the facility. Many different methods of control including habitat management, harassment, and population management can be utilized. Habitat management includes reducing access to feed and water. Birds will generally not roost in the same area as they feed. Feeding generally occurs over the middle of the day. Reducing the amount of feed available in the bunks during the middle of the day can be helpful. Altering feed delivery so that more feed is available during the evening and nighttime hours may help reduce losses. Also lowering the water level in drinking troughs to more than 6" from the top of the water will prevent birds from drinking while perching on the rim and maintaining a water depth of greater than 6" will prevent birds from standing and drinking.

### **Rodents**

Who fed the mice today? Losses due to rodents may be due to several factors. Rodents are generally attracted to feeds with higher fat contents. Waste due to holes in bags or increased spoilage associated with holes in silage covers may be a greater concern than the actual consumption of feed. Rodent control around silage piles includes excellent weed control and in some cases may involve the utilization of fencing to keep rodents away from the feed. In some cases, damage by other wildlife can also be significant. Deer, turkeys and raccoons can cause significant spoilage and consume significant amounts of feed.

### **Tires and Tracking**

Can you follow the feed loader by the soybean meal tracks? Wet tires are very efficient in tracking feedstuffs around the farm. Bumps are great for unloading feed at places other than the TMR wagon. Take a look around your farm. Where do you see feedstuffs in places other than the bunk, mixer wagon or feed loader bucket? What is the price of the ingredients you see scattered on the road or mixed with the dirt? Using a loader to transport high priced commodities, could be an issue if there is significant loss from the bucket during this movement. Consider how you might reduce the travel distance or make a premix of several commodities to reduce travel time and feed losses.

### **Tossed Feed**

Feed is an expensive cattle toy. Cattle tend to like to toss feed. Increase fly pressure will generally increase this activity. Post-and-rail feed barriers allow for more of this activity. Some studies estimate the feed loss is 2.5% less when headlocks are utilized as the feed barrier. This could amount to 3 pounds of feed per day or 1.5 pounds of dry matter per cow each day. Maybe your estimated feed intake is really only 53 pounds per day rather than the 54.5 pounds estimated by feed delivered minus feed refused. This could represent over 20 cents per cow per day.

### **Silage Bunkers**

Do you really want to know what this number is on your farm? A few years ago, I had the pleasure of helping a producer make significant changes in his silage management. Loss in the bunkers was running between 25-30%. In July of the following year, he called and asked why he still had several months of silage remaining. He had reduced his losses to about 10% and one benefit was he needed to purchase less the following fall. Reducing silo losses is a matter of correctly managing harvest,

filling, covering and feedout. The single most critical factor may be harvest moisture. Wet or dry plant material increases losses. Use of inoculants or preservatives may help reduce losses, but losses increase when the material is either too dry or wet. Chopping quickly, achieving a correct density and covering immediately after filling are key ways to reduce losses. Overfilling bunkers increases losses due to inadequate packing. Keeping feeding face vertical and sizing the face to fit the herd are critical factors in reducing losses during feeding. Many producers are getting total silo losses to near 5%. However, many still have issues to correct and are losing up to 30% of the forage that is harvested. A goal would be to get under 10% and then try to reduce it to near 5%.

### **Feed Refusals**

Do the leftovers become fertilizer? If so, you are using expensive fertilizer. Most of the refusals are still acceptable for some groups of cattle. Yes, there can be some biosecurity concerns however, these are generally minimal. Use of these feeds for the heifers, or limited use in dry cows is a way to reduce feed cost in these groups. Another potential use is for beef cattle. In areas where beef operations exist near dairies, the beef producer may be willing to purchase refusals.

Some producers are trying to feed for a slick bunk to reduce the amount of refusals. A normal practice would be to feed for 3-5% refusal. However, with high feed prices, many farms are trying to reduce this to a low level. Dairies that feed only once per day, have some significant challenges to feeding to a slick bunk. Adjustments to feed delivery are only made once daily and changes in intake make this very difficult to manage. Dairies that only feed during the daylight hours also have a challenge in ensuring that adequate feed is available over the night hours. This is especially true for summertime feeding when 60% of the feed may be consumed during the cooler nighttime hours. Farms feeding 18 or more hours each day may be better able to manage bunks to reduce refusals. Emphasis should be placed on ensuring that cattle have access to adequate feed 22 hours each day.

### **Bunk Heating and Spoilage**

Is your feed hot? Hot is not good when it comes to feed. When feeding high moisture feeds, someone should be checking each day to see if the diet is heating in the bunk. This is especially true during the summer. Heated feed is the result of secondary fermentation. It robs the ration of the most digestible nutrients. Energy is neither created nor destroyed it is transformed. As dairymen we want our cattle to transform the diet energy into milk, not heat in the bunk. Heated feeds also reduce feed intake. It is important to determine the cause of the heating. Poor silo face may be the root of the problem. Silage facers and correct silo face size are important factors in keeping the silage fresh. Sometimes, when low quality water (water high in bacteria) is added to the TMR, heating may result. Feeding more often during the day will also help reduce heating and losses due to heating. In some cases, feed additives may also be helpful in reducing the rate of bacterial and yeast growth to reduce secondary heating.

### **Feed Moisture Loss**

When wet feeds are delivered, ambient temperature, wind, sunlight and relative humidity become our enemies. These all combine to cause evaporation and loss of feed moisture. The longer we store the product, the greater the losses. Protection from wind and sunlight can help reduce the loss, however, to keep these losses low, daily deliveries are the best. In most cases, this may not be

possible. The goal should be to receive these feedstuffs several times per week or utilize silage bags for longer term storage. Some on-farm measurements of wet products stored on cement indicate that the moisture loss is about 1% each day. If products are going to be fed over a week, some ration changes may be necessary to account for the changes in dry matter over the feeding period.

### **Mixing Errors**

Are mixing error really feed shrink. The feed is fed to the cow, however, it is not fed correctly and can increase our feed cost and reduce the length of time a quantity of feed should last. A quick check is to determine how long it should be between deliveries of feedstuffs. Simply dividing the amount of product delivered by the amount fed each day should give an estimate of when the next shipment should be needed. If you are feeding 1,000 cows 4 pounds of soybean meal each day, a 25 ton load should last 12.5 days. However, near the end of 9 days, you realize that you will need a delivery the next day. This is about a 16% apparent loss or shrink. In looking at the feed records you discover that the feeder was to have added 500 pounds to each of 8 daily loads of feed. However, he had been adding 540 pounds to each load or 320 more pounds each day. Thus, about half of the loss was due to the mixing error. Careful attention to correct addition of ingredients is very important in reducing feed waste.

In reducing mixing errors, it is important to consider how much of a feedstuff is added to the TMR mixer. In general, feedsuffs that will be fed at less than 5 pounds per head per day should be mixed with other ingredients prior to the addition to the TMR mixer. Making on-farm premixes or purchasing premixes with several ingredients are preferred to making small additions. A bucket designed to hold 2000 pounds of silage does not effectively deliver 100 pounds of premix to a TMR wagon.

It is also important to watch the order of ingredient addition to the TMR mixer. Some employees may try balance the total load weight by the amount of the last ingredient added. If this ingredient is a high cost or of great importance to the diet, it may be either shorted or over-fed depending upon the errors made with adding prior ingredients. Sometimes it is good to have a low cost feedstuff as the last ingredient added or inform employees that it is more important to add the correct amount of all ingredients and to avoid shorting or adding additional amounts of another ingredient to balance the total load weight.

### **Scale Accuracy**

Scales are either electronic, mechanical or a combination. All require calibration and maintenance. Sudden stops or starts while on the scale platform can cause significant damage. Employee training is necessary to avoid scale damage. Scales should be certified at recommended intervals and keep in mind that certification means that the scale operates within a certain rage of accuracy. Several years ago, a friend was shipping grain to a processing plant. He had a scale on his farm and obtained load weights to compare with those of the processing plant. He noticed that each load was about 8-10 bushels lighter according to the processing plant tickets. He had his scale checked and checked with the processing plant, who assured him that their scales were also certified. He checked the trucks for leaks and made sure the drivers where keeping tarps on for the entire trip. Still the weights were off. On one trip he road along and discovered the issue. Each truck weighed on one scale when entering the facility and weighed on a second scale when exiting the facility. Yes, both scales were certified,

but this is not an exact science. If the incoming scale weighed close to the lower limit for certification and the outbound scale weighed close to the upper limit, then there is an issue. Use the same scale for both the tare and gross weights.

Scales on TMR wagons are subject to wear and tear. Bouncing around the dairy can cause damage and electrical cords can be damaged. A good management practice is to run the TMR mixer over the farm scales a couple of times each month to ensure that it is still accurate.

### **Water Damage**

Moisture can easily damage minerals and vitamins. It also may result in mold growth in other dry feeds. It adds weight that reduces the amount of dry matter fed unless adjustments are made. Keep in mind that rain also cleans the mold and bacteria from the air and deposits it onto your feedstuffs. Piles of dry feed in bunkers are prime examples of potential feed loss on your farm. Protecting feeds from moisture is important. Bunkers with dirt floors and round bale sidewalls are a guaranteed way to increase feed cost.

### **Conclusion**

In most cases, the factors discussed above represent a potential 10-15% decrease in feed cost for most dairies. This does not mean that you will get feed shrink to zero or in most cases even near zero. It should be our goal to get forage losses below 10% and work toward 5%. Purchased concentrates should be below 5%. Commercial feed mills generally run less than 1%. Therefore, we have a lot of opportunity in this area. Milk prices and feed prices during 2009 will force dairies to be more efficient. Cutting feed shrink may be one of your best ways to improve your bottom line during the current year. In addition, your dairy will benefit every year from lessons learned.