

proceedings of the

2nd
Western
Large Herd
Dairy Management
Conference



Las Vegas, Nevada
April 5-8, 1995

Program:

Thursday April 6

Section Chairman: Ruth Blauwiekel, Washington State University

- 9:15 a.m. **Welcome** — John Smith, New Mexico State University
- 9:25 **“Optimizing BST Response Through Nutrition And Feeding Management”**
Carl Coppock, Coppock Nutritional Services, Laredo, TX
- 10:05 **“Reproduction And Health Management In BST Herds”**
James Ferguson, University of Pennsylvania
- 10:45 **“Economics Of Using BST”**
John Smith, New Mexico State University
Ken Bailey and David Hardin, University of Missouri
- 11:25 **“Making BST Work: The Producer Experience”**
Romulo Escobar Valdez, Escobar Dairy, Juarez, Mexico
Ron St. John, Alliance Dairies, Trenton, FL
Tom Thompson, Stotz Dairy, Buckeye, AZ
- 12:25 p.m. LUNCH

Section Chairman: Don Klingborg, University of California-Davis

- 1:45 **“Footwarts In Dairy Cattle: Current Understanding Of A Complex Disease”**
Richard Walker, University of California-Davis
- 2:25 **“Colostrum Management: How Good Is Your Program?”**
Frank Garry, Colorado State University
Scott Wells, USDA/APHIS Veterinary Services
- 3:05 BREAK
- Section Chairman: Bill Wailes, Colorado State University*
- 3:20 **“Rational Treatment Of Clinical Mastitis”**
Walt Guterbock, U.C. Davis
- 4:00 **“Neosporosis: A Newly Recognized Cause Of Abortion In Dairy Cattle”**
Pat Conrad, U.C. Davis

Friday April 7

Section Chairman: Dennis Armstrong, University of Arizona

- 8:30 a.m. **“Design And Performance Of Milking Systems”**
Graeme Mein, University of Wisconsin
- 9:10 **“Making Manure Nutrient Management Work For You”**
Deanne Morse and Larry Schwankl, U.C. Davis
- 9:50 **“Freestall Housing Design For Comfort & Convenience”**
Dan McFarland, Penn State University
- 10:30 BREAK

Section Chairman: Richard Norell, University of Idaho

- 10:45 **“Dairying In The Future: Some Questions You May Want To Ask”**
Rich Cotta, San Joaquin Valley Dairymen, Los Banos, CA
- 11:25 **“Economic Decision Support Systems For Dairies”**
Mike Delorenzo, University of Florida
- 12:05 p.m. LUNCH

Section Chairman: Chris Woelfel, Texas A&M University

- 1:25 **“Resolving Conflict In Family-Owned Agricultural Businesses”**
Guy & Michelle Hutt, University of Southern Maine
- 2:25 **“Economic Impact Of Bull Choices, A.I. Or Otherwise”**
Ben McDaniel, North Carolina State University
- 3:05 BREAK

Section Chairman: Don Bath, University of California-Davis

- 3:20 **“Managing The Milking Parlor For Profitability”**
Dennis Armstrong, Univ. of Arizona; John Smith, New Mexico State Univ.; Craig Thomas and Dave Bray, Univ. of Florida; Mike Gamroth, Oregon State University
- 4:00 **“Economical Feeding And Management Practices For Herds Approaching 30,000-lb. Rolling Herd Averages”**
Brad Houston, Price's Roswell Dairy, Roswell, NM
Dennis Lagler, Lagler's Dairy, Vancouver, WA

Saturday April 8

Section Chairman: Ron Bowman Utah State University

- 8:30 a.m. **“Feeding To Make Money: Managing Nutrients In The Total Herd”**
Charles Sniffen, Miner Research Institute, Chazy, NY
- 9:10 **“Management Strategies For TMR Feeding Systems”**
Jim Spain, University of Missouri
- 9:50 **“Minimizing Transitional Stress For Close-Up Dry Cows: Field Experiences And Applications”**
Jimmy Horner, Horner Nutrition Service, Decatur, TX

10:30 BREAK

Section Chairman: Mike Gamroth, Oregon State University

- 10:45 **“Facts And Fallacies About The Uterus After Calving”**
Donald Klingborg, U.C. Davis
- 11:25 **“Dairying And The New Social Ethic For Animals”**
Bernie Rollin, Colorado State University
- 12:05 CONFERENCE ADJOURN

Welcome!

to the 2nd Western Large Herd Dairy Management Conference, presented by the Cooperative Extension Services from the Western United States. We have prepared a program that we believe will assist you in continuing to be the leaders in the world's most efficient milk production industry, and thereby in maintaining a healthy industry.

*Dennis Armstrong, University of Arizona – Co-chairman
Mike Gamroth, Oregon State University – Co-chairman
John Smith, New Mexico State University – Co-chairman
Donald Bath, University of California-Davis
Ruth Blauwiekel, Washington State University
Ron Bowman, Utah State University
Dennis Halladay, The Western Dairyman Magazine
Donald Klingborg, University of California-Davis
Richard Norell, University of Idaho
William Wailes, Colorado State University
Chris Woelfel, Texas A&M University*



Conference Organizing Committee members (kneeling and seated l-r): Chris Woelfel, Mike Gamroth, John Smith, Don Bath, Ruth Blauwiekel, Dennis Armstrong, and Richard Norell. (Standing, l-r): Donald Klingborg, Ron Bowman, and Bill Wailes.

Index Of Presentations:

	<u>page</u>
“Optimizing BST Response Through Nutrition And Feeding Management” by <i>Carl Coppock</i>	5
“Bovine Somatotropine: Effects On Reproduction” by <i>James Ferguson</i>	11
“Financial Implications Of BST” by <i>John Smith, Ken Bailey and David Hardin</i>	19
“Making BST Work: The Producer Experience” with dairy producers <i>Ron St. John, Tom Thompson and Romulo Escobar Valdez</i>	27
“Footwarts In Dairy Cattle: Current Understanding Of A Complex Disease” by <i>Richard Walker</i>	33
“Colostrum Management: How Good Is Your Program?” by <i>Franklyn Garry and Scott Wells</i>	41
“Rational Treatment Of Clinical Mastitis” by <i>Walter Guterbock</i>	49
“Neosporosis: A Newly Recognized Cause Of Abortion In Dairy Cattle” by <i>Patricia Conrad, Mark Anderson, and Bradd Barr</i>	61
“Design And Performance Of Milking Systems” by <i>Graeme Mein</i>	69
“Making Manure Nutrient Management Work For You” by <i>Deanne Morse and Larry Schwankl</i>	79
“Freestall Housing Guidelines: Details To Enhance Management” by <i>Dan McFarland</i>	89
“Dairying In The Future: Some Questions You May Want To Ask” by <i>Richard Cotta</i>	103
“Economic Decision Support Systems For Dairies” by <i>Mike DeLorenzo and Craig Thomas</i>	113
“Managing Conflict In Agricultural Businesses” by <i>Guy Hutt</i>	125
“Economic Impact Of Bull Choices, A.I. Or Otherwise” by <i>Ben McDaniel</i>	133
“Managing The Milking Parlor For Profitability” by <i>Dennis Armstrong, Craig Thomas, John Smith, Mike Gamroth, and David Bray</i>	139
“Economical Feeding And Management Practices For Herds Approaching 30,000-lb. Rolling Herd Averages” with dairy producers <i>Bradley Houston and Dennis Lagler</i>	147
“Feeding To Make Money: Managing Nutrients In The Total Herd” by <i>Charles Sniffen</i>	153
“Management Strategies For TMR Feeding Systems” by <i>Jim Spain</i>	161
“Minimizing Transitional Stress For Close-Up Dry Cows: Field Experiences And Applications” by <i>Jimmy Horner</i>	169
“Facts And Fallacies About The Uterus After Calving” by <i>Donald Klingborg</i>	173
“Dairying And The New Social Ethic For Animals” by <i>Bernard Rollin</i>	179

Proceedings of the 2nd Western Large Herd Dairy Management Conference

Editor – Mike Gamroth, Oregon State University
Layout & Production – Dennis Halladay, *The Western Dairyman Magazine*

Optimizing BST Response Through Nutrition And Feeding Management

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BST is here. Now the challenge is to maximize profit through its use. Someone said, "BST is a shortcut to genetic progress." Genetic progress for milk in Holsteins has been about 260 lbs per year. In 10 years this is 2,600 lbs. If BST is used beginning at 63 days postpartum and it is continued for 242 days and an average response of 10 lbs/day is obtained, then 2,420 lbs more milk will be obtained in one lactation. This is equivalent to over 9 years of genetic progress in one lactation. Adopting BST is like a very sudden shift to a higher gear in a machine with an engine capable of delivering the torque to move at the higher speed.

Studies with the respiration chambers at USDA-Beltsville, MD, showed that neither digestive nor metabolic efficiency was changed when BST was used. Therefore, the increased milk which occurs with BST use must be paid for with increased feed. There is no free lunch with the increased milk from use of BST. Cows respond to BST in 3 ways:

- a). They produce more milk.
- b). After a lag they eat more feed.
- c). They produce more heat.

Therefore, use of BST affects two primary management systems: nutritional management and environmental management.

Nutritional Management – Dry Period

The dry period presents a window of opportunity to:

- a). Replenish nutrient reserves if needed.
- b). To prepare tissues of the cow for the stresses of parturition and lactation which follow.
- c). To eliminate mammary gland infections if they are present.

Stopping the use of BST should be part of the drying off procedure because production will decline following its removal. Body condition score should be about 3.5 at the end of the dry period. This simple, though subjective, method of evaluating body energy reserves is one of the most useful and critically needed tools to make the results of BST a continuing success. For whatever reason(s), a number of cows are finishing lactation without the nutrient reserves needed to begin a new lactation with the

production which they are capable of achieving. Therefore, the dry period provides the time to restore these reserves and body condition score is the tool to show how much replenishment is needed.

The NRC (1989) gives a pregnancy allowance for energy of about 30% of maintenance. Both can be met by 25 lbs. of an excellent grass hay. With regard to lead feeding, I recommend 4-6 lbs./cow/day during the three weeks prepartum, of the concentrate fed to the lactating cows. Oetzel et al. (1988), showed that even with prepartum diets high in calcium, 100g/d each of ammonium chloride and ammonium sulfate for 21 days prepartum reduced the incidence of milk fever from 17% to 4% in 48 Holstein cows. I suggest to use these anionic salts with great caution.

Nutritional Management – Postpartum Cow

Under drylot housing, the totally mixed ration (TMR) system in which cows are fed for ad libitum consumption is a superb way to feed cows. Definition: A TMR is a quantitative mixture of all dietary ingredients, blended thoroughly enough to prevent separation and sorting, formulated to specific nutrient levels and offered free choice. When cows are given a choice of feeds, a significant minority of cows will "unbalance" their rations. Examples of choices include:

- a). alfalfa hay vs. corn silage
- b). mineral supplements
- c). whole cottonseed vs. other feeds.

Diet formulation should begin with comprehensive water, forage and feed testing. Drinking water may carry from 50% to 100% or more of the requirements for sodium, sulfur, chloride, and other mineral elements. The reason book values cannot be used for precise formulation is that there is great variation in economically important nutrients. And probably greater variation occurs in most of the byproducts than occurs in conventional feed grains.

In formulation, one should consider:

- a). cost
- b). palatability
- c). predicted dry matter (DM) intake (optimal water)

- d). energy (NEI), fats, nonstructural carbohydrates
- e). fibers, ADF and NDF
- f). protein, with a range in degradable/undegradable protein
- f). 7 macro and 7 micro mineral elements, including buffering capability
- h). water consumption and composition
- i). excesses as well as deficiencies.

The intended nutrient profile in the final mixture should be confirmed. Strive for maximal energy in early lactation. We won't be able to close the gap between feed energy eaten and energy required, but with good nutritional management, it is possible to elevate both curves. However, if there is a weakness or deficiency in the formulation, it will likely manifest itself more severely with use of BST.

An advantage for feeding supplemental fats (SF) is the increased energy density and the lower starch which results if the SF is substituted for cereal grains. This suggests that by increasing energy density, an increase in energy consumption will result. This is true if dry matter intake is maintained or nearly so. Negative effects sometimes occur with SFs; these include lower fiber digestibility, reduced feed intake, and usually reduced milk casein synthesis. But both forms of SF are needed: oilseeds and ruminally inert fats.

Use of BST will cause an increase in milk yield within 2-4 days of first use, although maximal response requires 4 to 6 weeks of continuous use. A recent survey showed that dairymen were getting an average of 10.7 lbs of milk per cow per day from BST use. Ten pounds of additional milk will require about 4 lbs more of feed dry matter of a well balanced TMR. But there is a lag of 4-6 weeks before the appetite increases for the additional feed. During this lag period, the nutrients to pay for the additional milk must come from body stores, feed, or a combination of the two.

There is no free lunch here; the increase in milk yield must be paid for with feed nutrients at some point. Feed nutrients must be available when the appetite increases so that cows have the chance to replenish nutrient reserves as lactation advances. A recent study from Michigan (Speicher et al., 1994) shows that the effects of BST and 3X milking are additive, but not completely so. The primiparous cows responded more to the combination of 3X and BST than did the multiparous cows (see Table 1 below).

Heat Stress Management

Remember, as Dennis Armstrong says: "a cow is a little furnace!" The greater the feed intake, the hotter the furnace. As body temperature increases, the

cow responds by reducing her feed intake, probably as a protective mechanism, and milk production soon drops. During heat stress, a behavioral response of cows fed feeds separately is to reduce hay intake more than or before concentrate. Therefore, fiber intake is reduced with possible problems under this feeding system.

Some nutrient requirements are increased by heat stress:

- a). Largely as a result of panting, a heat-stressed cow will have an energy requirement for maintenance of 120-130% of normal.

Table 1: Effect Of BST And Milking Frequency (2X vs. 3X) on Daily FCM Production By Multiparous And Primiparous Holstein Cows*

	Control		BST		Diff. due to BST
	No. Cows	FCM lbs/day	No. Cows	FCM lbs/day	
Multiparous					
3X	16	75.4	16	80.9	5.5
2X	17	65.0	14	78.7	3.7
Difference		10.4		2.2	
Primiparous					
3X	14	65.7	14	75.8	10.1
2X	13	58.6	14	70.8	12.2
Difference		7.1		5.0	

*Speicher et al., J. Dairy Sci. 77: 2509. 1994.

panting, a heat-stressed cow will have an energy requirement for maintenance of 120-130% of normal.

b). Up to 50% more water will be drunk. As long as the drinking water is cooler than the body temperature of the cow, the consumed water adsorbs some of the cow's body heat. So if one is fortunate to have cold well water, do not bring that cold water up to an open trough where it will warm up, but keep it shaded or use one of the insulated tanks to keep it cold until the cows drink it.

c). Potassium: increase to 1.3-1.5% (West, 1994).

d). Sodium: increase to .35%

e). Magnesium: .35% (West, 1994)

f). Chlorine: .35%?

Are there dietary adjustments that will maintain net energy intake and simultaneously reduce metabolic heat production?

- Chandler (1994) noted that some feed ingredients have lower heat increments than others, and that these should be emphasized in hot weather. Heat increment is defined as the increase in heat production which occurs when animals eat feed. For example, feeds with low heat increment include whole cottonseed, roasted soybeans, tallow and the ruminally escape fats. Low fiber ingredients usually result in less HI than high fiber feeds — corn silage less than most hays.

- Both dietary deficiencies and excesses cause extra heat production.

- Degradable protein and undegradable protein in the appropriate relationship has

reduced heat stress in some trials.

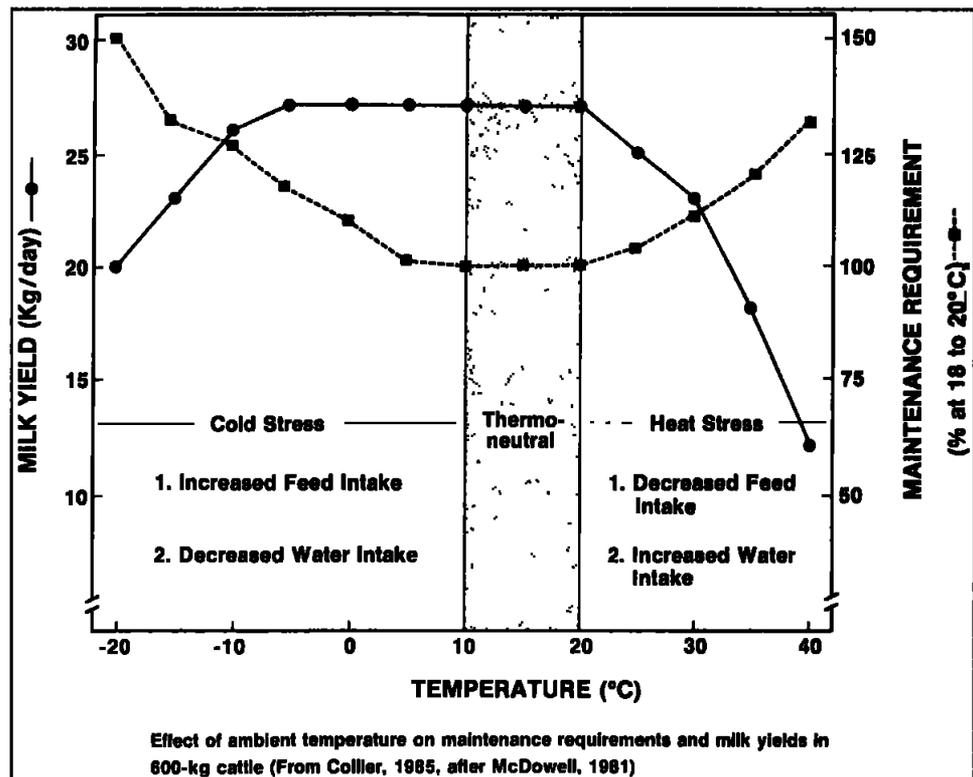
High yielding cows produce more heat than low yielding cows. Technologies not economic at low production may become so at yields achievable with BST. In other words, use of BST will help to pay for the heat stress technology which allows it to work in hot weather.

Shades. The black and white cow does not belong in the sun in the Southern U.S. during summer.

a). In a Georgia summer study (West et al., 1990), cows with shade as the only heat stress alleviation and given BST produced more milk, ate equal dry matter (DM), had higher body temperatures, but lost body weight and condition.

b). In an Arizona study (Huber, 1994) from March through August, cows given BST maintained a 10 lbs. advantage over controls, even though both groups dropped more than 20 lbs. per day during this interval. But the cows in this study were cooled with high technology evaporative coolers.

c). Relevant to more humid areas, Florida work-



these two devices – 1.5 minutes sprinkling and 14 minutes of fan. These are especially valuable in the holding areas as well as in freestall barns and over cows at the feed manger.

Armstrong (1994) has an excellent summary on cooling options with the following priorities:

- a). Solid shade for all milking and dry cows.
- b). Holding pen cooling.
- c). Exit lane cooling.
- d). Corral shade cooling.
- e). Feed manger cooling.
- f). Covered feed manger.

Other Management Features

Use of BST will make longer calving intervals (C.I.) more profitable. Over 10 years ago, Holmann et al. (1994) showed that in contrast to the usual recommendation of a 12-mos. C.I. as being ideal, 13 months actually produced slightly more income over feed cost per cow per day of C.I. (\$4.11 vs. \$4.08), and a 15-mos. C.I. showed no substantial loss (\$4.08) compared to 13-mos. This was a budgeting simulation study which assumed that TMR income maximizing rations were fed, 65 days dry were provided, and 30% of the cows were <36 mos. of age and 70% were older than 36 mos.

As Ferry (1994) recently noted, "Regardless of breeding strategy, BST supplementation prolongs the period of profitable production, widening the window of opportunity to achieve conception, and increasing average herd life". In turn, cows that fail to rebreed or are deliberately marked to not rebreed will have longer and more profitable herd lives through the use of supplemental BST.

Summary:

1. Use of BST makes cows of all genetic abilities better cows that produce more milk. When they eat more feed, they produce more heat.
2. Greater milk yields mean correspondingly greater nutrient requirements; fortunately, increased appetite occurs in BST treated cows some 4-5 weeks after treatment begins, which allows restoration of body reserves in later lactation if feed nutrients are available.
3. Diet formulation should be comprehensive and based on detailed feed and water testing.

4. Some nutrient requirements are increased by heat stress, but careful diet formulation can resolve most of these.

5. A cow is a little furnace — she has much heat to get rid of. Some reduction in heat production by the cow can be achieved by selection of feedstuffs which have lower heat increments.

6. An array of technologies is now available to help the cow dissipate the large amount of heat she produces, plus the heat she receives from her environment. Use of BST will help to pay for the heat stress technology which allows it to work in hot weather.

7. In summer, cows will produce as much milk as the heat stress management allows them to produce. We have bred dairy cows to be heat-generating animals, metabolic thoroughbreds that will punish themselves with elevated body temperatures and sharply increased respiration rates in order to sustain the high yields they were bred to produce. If continuing increases in yields are to be sustained, cows must have protection from the high radiant heat of summer, have help in dissipating the large amounts of heat they produce, and receive diets which minimize the heat associated with the digestion and metabolism of feed.

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notes

Bovine Somatotropin: Effects On Reproduction

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Reproductive efficiency effects profit in dairy herds by influencing milk produced per day, calves born per year, and replacement losses from forced culling^{4,7,9,13}. Since rates of return are 3/1 in early lactation compared to 1/1 in late lactation, and 50% of profit from milk production is realized in the first 100 days of lactation, profit and cash flow are potentially maximized when cows calve every 12 months, given typical lactation profiles. The optimal time period between successive calvings (calving interval (CI)) is a function of the shape of the lactation curve, replacement calf value and future potential survival in the herd⁴. Altering the lactation function by using bovine somatotropin may alter the optimal CI.

Bovine somatotropin (BST) increases milk production post peak lactation and has a slightly negative effect on conception rate (CR)^{1,5,6,17,18,19}. Due to the lower CR, CI has been longer and fewer cows have become pregnant when given BST and voluntary waiting period has not been altered (Table 1). Since BST increases milk production post lactation peak, it has been speculated that it may be more profitable to have a longer CI in cows receiving BST. In addition, although fewer cows may become pregnant, BST may be used to extend lactation in open cows, thus reducing the negative effects of fewer pregnant cows on milk produced per day. However, extended CI and fewer pregnant cows may decrease returns if these are bad decisions economically. Many studies have examined the economic aspects of using BST based on milk yield response and cost of BST⁸, but few studies have examined the interaction of BST use with reproductive management on farm profit. This paper will explore those issues.

Calving Interval And BST

Calving interval is a function of conception rate (CR), heat detection rate (HDR), voluntary waiting period (VWP) and breeding period (days following the VWP which cows will still be inseminated). Conception rate influences semen usage. Heat detection and conception rate determine pregnancy rate (PR, the proportion of cows which become pregnant every 21 days). Pregnancy rate is the param-

eter that determines CI and calves born per year. Combined with the PR, the breeding period will determine the total pregnant animals. Decreasing CR and/or HDR and extending the VWP increase the CI. This reduces milk/day and calves born/year, thereby reducing herd profit. Pregnancy rate (PR) captures the effects of HDR and CR in one variable. In dairy herds it is profitable to achieve 85% pregnancy or higher in cows which are in the breeding pool, and profit is maximized when 80% of cows become pregnant prior to 120 days postcalving at a PR of 35%.

Using lactation data from a 400-cow dairy, we examined production responses through two lactations for cows with VWP of 50, 80, 110, 140 days and 100% PR. We modeled production for 50 cows, 35% first lactation, 20% second lactation, and 45% third and greater lactation, through two sequential lactations. Initially, we did not consider replacement, but were interested reproductive factors which resulted in maximum production in this cohort of cows over this time period. Voluntary waiting period could be varied, as could PR and breeding period. Initial breeding period was set to 270 days from the VWP and could be extended to 420 days from the VWP.

As days open increase from 50 through 140 days, milk declines by .06 lbs/day (Figure 1). Thus, it is most profitable to get cows pregnant early. To investigate the effects of BST on this relationship we then examined injections from the ninth week of lactation.

Posilac® (Monsanto) is approved for use in lactating dairy cows from the ninth week of lactation⁵. Typical production responses have been 8-15 lbs. of milk. Injections must be given every 14 days to maintain the production response. Production response declines slightly in cows over 200 days in milk⁵. Production oscillates with the 14-day injection schedule, peaking 7-10 days post injection. We examined production responses of 5, 10, and 15 lbs. with varying VWP and PR to examine the effect of BST on milk/day over two sequential lactations. Injection was given beginning the 9th week of lac-

TABLE I. Summary of studies examining bST effects on milk production, conception rate and total pregnant animals.

Increase in from controls Milk (kg)	0	0-2.5	2.5-5.0	5.0-10.0	>10
Number cows,	66	40	404	338	848
Mean increase, kg	4.78	.13 (10.5 lb)	.29		

(summary of 27 trials)

bST and Pregnancy, number of cows

BST	OPEN	PREGNANT	%
0	123	1043	89.5
YES	158	690	81.4

MANTEL HAENSZEL CHI SQ 64.51 p<.000
(summary of 27 studies)

BST - CR and DAYS OPEN

	Control	bST
CR,%	48.4	47.2
Days Open	0 ^a	17.2 ^b

(summary of 14 - 19 trials)

tation and response could be varied to exam the interaction of BST with days open.

Again, PR was set to 100%, VWP was varied from 50 to 140 days and BST response was 0, 5, 10 or 15 lb. (Figure 1). In this case the VWP would represent days open. Milk produced per day decreased .060 lbs/day from 58.82 lbs/day as days open increased from 50 to 140 days. If BST caused a 5 lb. increase in milk, baseline milk increased to 61.99 lbs/day, but increasing days open was still associated with a .055 lb/day decline in milk produced per day. If BST increased milk 10 lb., then baseline production was 65.22 lbs/day and the decline in production per day was .051 lbs/day. With a fifteen pound increase in milk from BST injections, baseline milk was 68.47 lbs/day, but still declined at .046 lbs/day with increasing days open (Figure 1). The decline in milk with extended days open was reduced with increasing BST response but not abolished. Using BST minimized losses in milk/day with extended days open,

but highest production was associated with 50 days open.

However, dairy herds do not have PR of 100%. The average herd has a PR of 25%, and most herds range from a low of 15 to a high of 35%. Therefore herds have cows with varying distributions of days open as a function of PR. At very low PR (<=30%) milk/day declines steeply (Figure 2). Extending the VWP to 80 days across all PR reduces milk/day, but the decrease is not as great at PR below 35% (Figure 2). Injections of BST, resulting in 5, 10, or 15 lb. of milk response, increase milk/day above baseline rates across all PR, but production is maximal when PR is above 35% (Figure 3). Low PR extend CI, lower milk produced per day and calves born per year. Injections of BST increase milk/day at any given level of PR. However, milk/day is maximized with VWP of 50 days and PR equal to and above 35%. Thus, it does not appear that extending CI is the best decision to maximize milk production with BST. It

would appear to be optimal to maintain short CI with BST.

Interactions with Periparturient Problems

Cows with periparturient problems may have reduced fertility and reduced production. It has been suggested that extending CI would decrease the yearly costs associated with periparturient problems, and by using BST, lactations could be profitably extended to offset the losses associated with extended CI. To investigate these interactions, incidence of periparturient problems was varied from 10 to 50% with reduction in fertility of from 25 to 90% and production declines of 10 to 30% in cows with problems.

If the incidence of periparturient problems ranges from 10 to 30% and milk production declines by 10% in these cows, milk/day is reduced at all PR (Figure 4). The horizontal lines in figure 4 represent

the minimum and maximum milk/day if the incidence of periparturient problems is 0% at PR is <20% (minimum) and PR>70% (maximum). Increasing PR above 40% increases milk/day within ranges observed with no periparturient problems, but not to levels of 0% disorders. Extending VWP at typical PR of .25 in herds would be a costly decision. To delay breeding 30 days because of periparturient problems would reduce milk 2.1 lbs/day, at a PR of .25. It would only be profitable to make this decision if the cost of health interventions was more than the milk loss. However, to delay because of problems also reduces production/day in normal cows. Thus, this appears to be a bad decisions.

If BST increases milk 5, 10, or 15 pounds, then it can mitigate the production losses with periparturient problems (Figure 4). However, only BST in combination with short VWP and high PR can restore

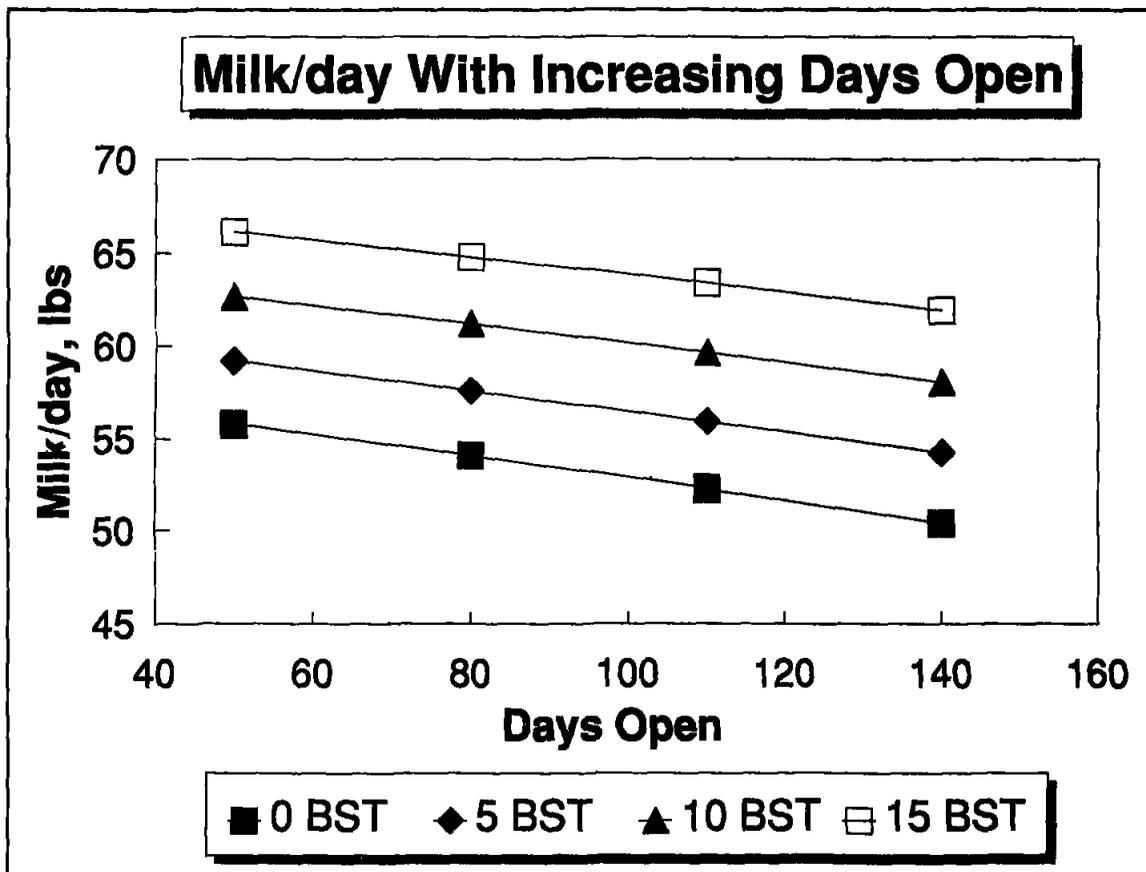
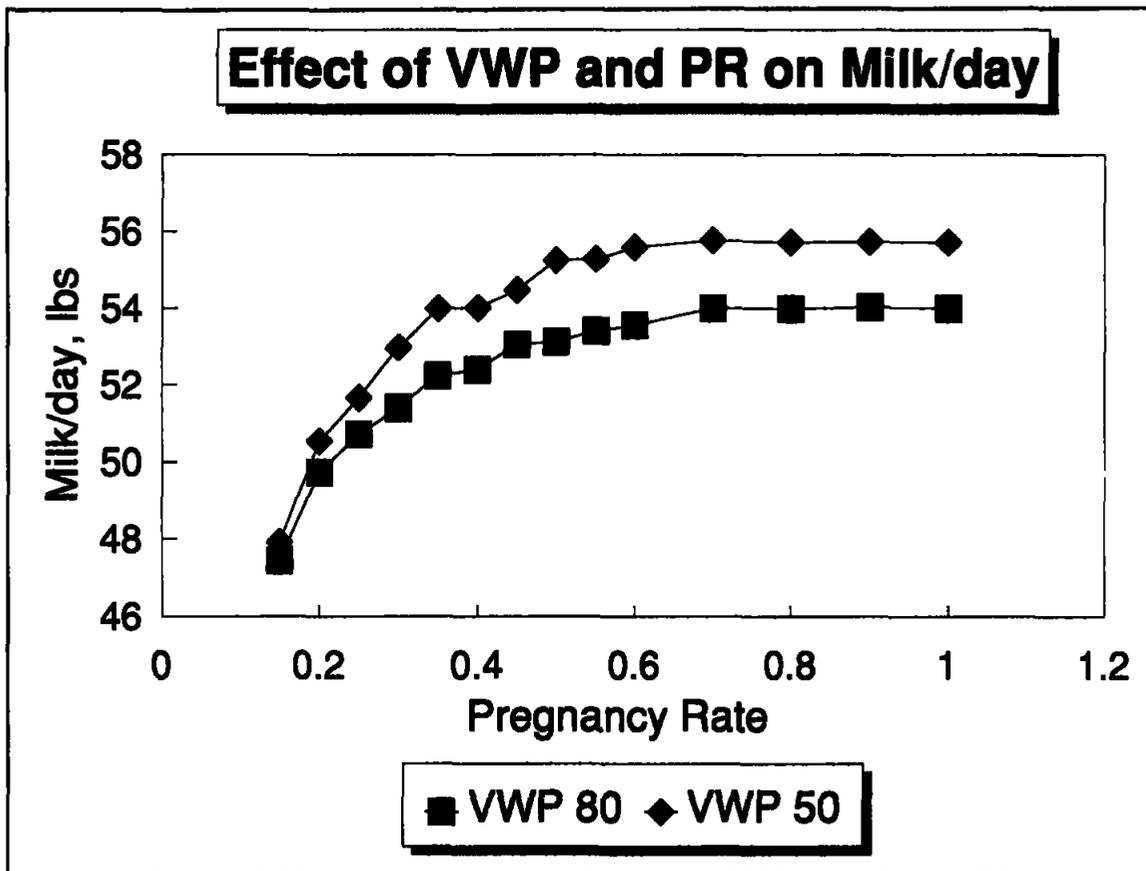


Figure 1.

Figure 2.



milk/day to levels achievable with no periparturient problems and high reproductive efficiency. If BST response were 10 lb. or more and milk losses with periparturient problems were 10%, then milk produced/day would approach baseline values if PR were 30% or higher. However, it should be noted that these levels don't approach maximum yields if periparturient problems were 0%.

Management Conclusions

Thus it appears reproductive efficiency and strategies should not be altered with BST. BST may offset some of the negative effects of low PR (<35%) common in most herds by increasing milk/day.

Reproductive Effects - Overview

Pregnancy Prevalence. Presented in Table 1 is PP for control and BST treated cows summarized from literature reports (3,5,10,17,18). PP was significantly reduced in BST treated cows. Pregnancy was most effected in primiparous cows in data summarized by Cole et al. (3). Older cows, the effects of BST on pregnancy seemed to be largely a function of milk yield (3). If milk yield increased in a predictable fash-

ion to BST injection, then PP was slightly reduced, and the reduction was consistent with increased milk yield (3).

Conception Rate and Days Open. Overall, cows receiving BST had slightly lower CR (5) to no significant reduction in CR (3,5 and Table 1). Days open increased (Table 1). Under current management schemes, with voluntary wait periods of 50-60 days, BST use will lower PP, but in a manner consistent with increased milk yield. CR in the fertile population will be similar to current CR, but total semen use may increase due to an increase in cows failing to become pregnant earlier. This early depression in CR may be related to energy balance and initial losses in body condition just after initiation of BST (14-16,19). Feeding management will interact with reproductive management and influence the CR response seen in individual herds.

Cows failing to become pregnant may actually stay in the herd longer, due to BST injection prolonging lactation yields. Thus although increasing forced replacement, herd turnover per year may

decrease, as cull cows may be milked longer due to BST injection.

Physiologic Effects On Reproduction

Changes in endocrine pattern in BST treated cows have been slight. Several studies have shown BST treatment is associated with increased plasma progesterone^{11 12}. GnRH induced luteinizing hormone (LH) output from the pituitary was higher in BST treated cows, and LH pulse frequency increased in BST treated cows¹². These slight changes in progesterone and LH are difficult to interpret relative to their potential impact on reproductive function.

Most studies have reported no effect of low to average doses of BST on expression of estrous or estrous cycling. High doses of BST have been reported to increase estrous cycle length and decrease estrous expression. Most studies suggest

little effect on first ovulation, estrous cycle length and estrus expression.

High doses of BST (≥ 50 mg/d) have been reported to increase early embryonic death. Initiation of BST in cows during early pregnancy (25 to 40 d postbreeding) should probably be avoided. This may explain why PP decreases with no change in CR in the cows which become pregnant. Cows which fail to maintain pregnancy may fail to become pregnant, whereas cows which maintain pregnancy due so in a fashion consistent with herd performance.

Extrapolating from field studies and based on the time postpartum of initiation of BST injection, the effects of BST on the physiology of reproduction appear to be minor and will not present major problems to dairy producers.

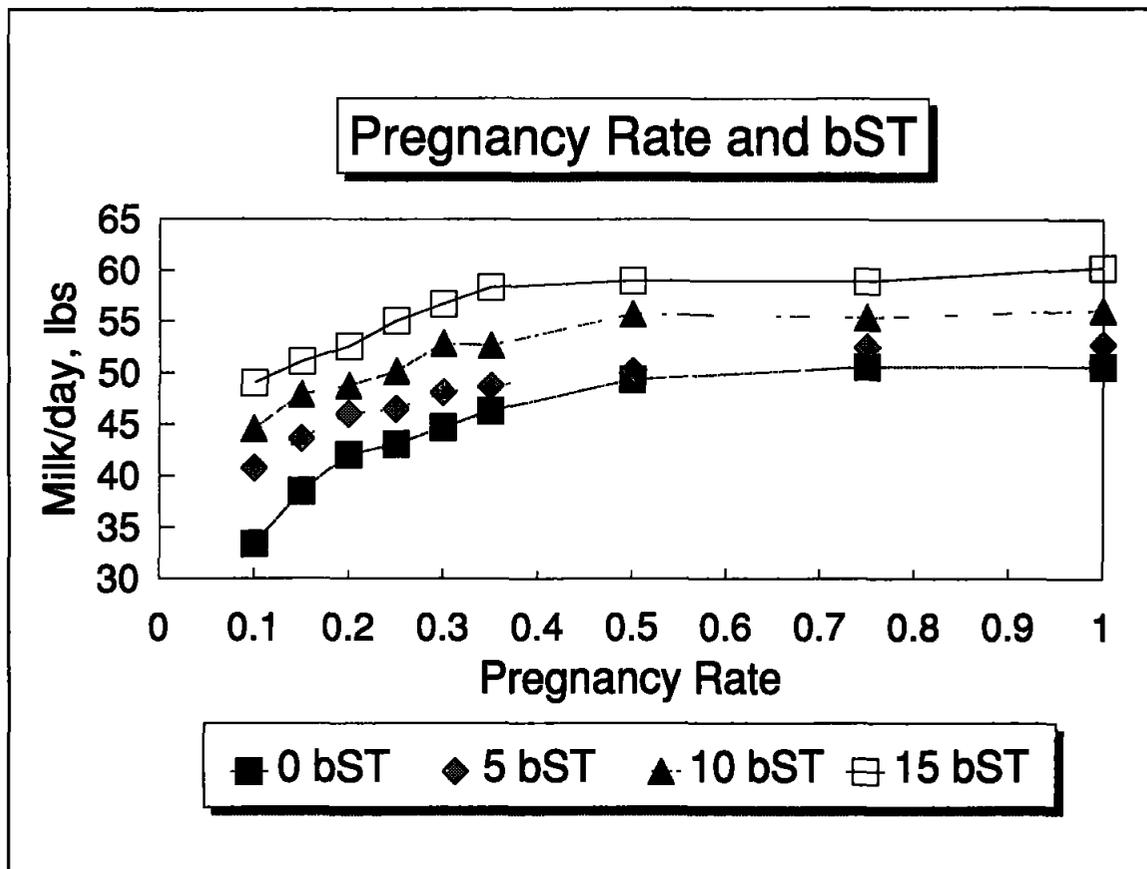
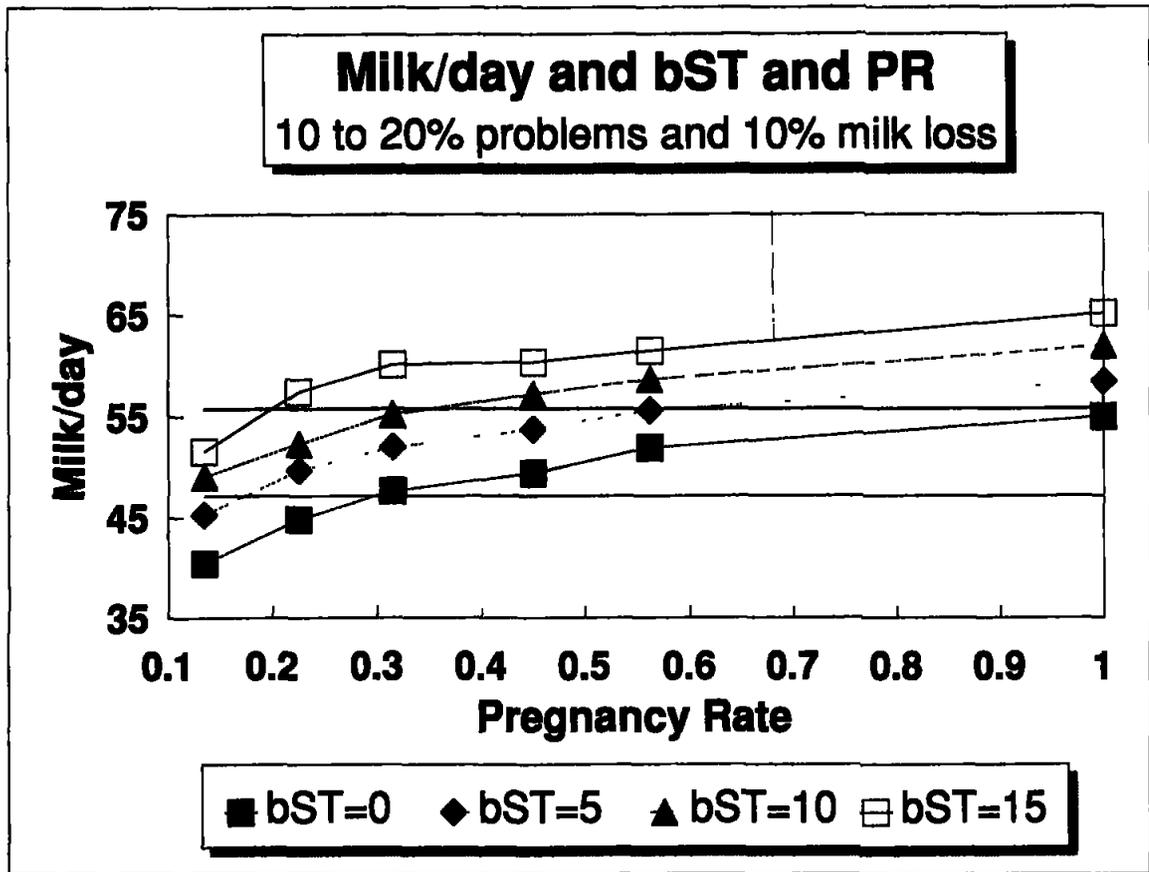


Figure 3.

Figure 4.



Weight Change And Body Condition

Most studies have reported less weight and body condition gain in BST-treated cows^{1,2,5,15,16,18,19}. Initiation of BST treatment decreases energy balance. Dry matter intake increases, usually 4 to 8 weeks after BST initiation (5). A decrease in energy balance does not mean cows are returning to negative energy balance. They may only be less positive, particularly with BST initiation at 60 days postpartum. BST partitions nutrients from body tissue to milk, so it is not surprising that BST cows gain body weight and body condition slower than nontreated cows. In most studies, condition by next calving was not different in the BST cows. Thus body repletion occurs, but producers will have to monitor condition change in late lactation to ensure adequate body reserves for next lactation. This does not appear to be different than current practices used to manage body reserves in high producing herds.

Managing rations to minimize change in body condition with initiation of BST should aid in preventing reduction in CR in the first month after BST treatment.

Milk yield responses to BST injection in cows

treated for two and three successive lactations have shown responses equal to the first year response (26,28,46). With proper management of body reserves, cows will respond equally well to BST in subsequent lactations.

Conclusion

Bovine somatotropin is a management tool which can be used to alter production within a herd of cows. Maintaining reproductive efficiency with BST is important to optimizing herd production, just as it is without BST use.

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Financial Implications Of rBST

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Recombinant bovine somatotropin (rBST) first became available to U.S. dairy producers in February, 1994 after Food and Drug Administration approval. The product approved, called Posilac, is manufactured and marketed by Monsanto Company. As new technologies such as Posilac become available, it is essential that dairy producers understand how to use them profitably.

A number of factors effect the profitability of cows supplemented with rBST. Some of these include: feed and labor cost, price of the product, milk price, and achieved milk production response. Other factors that affect the profitable use of rBST are number of cows milked, times per day milking, and percent of the herd receiving rBST treatment.

The objective of this paper is to evaluate the economics of rBST in a commercial setting for large dairy herds. We will consider the financial implica-

tions of rBST in terms of the whole herd, and on a per cow and per hundredweight (cwt.) basis. We will also consider rBST use under 2 times and 3 times a day milking. Information presented in this paper will help dairy producers develop a profitable program to effectively use rBST.

Feed Cost

The dry matter intake of the dairy cows supplemented with rBST will increase 2-7 weeks after the initiation of treatment. Rations should be balanced to meet the requirements for body condition and milk production.

The amount of energy required to produce an additional pound of milk is .31 Mcal(4). This assumes that the maintenance requirements of the cow have been satisfied. If a ration contains .78 Mcals per pound of dry matter, a dairy cow will have to consume an additional .397 pounds of dry mat-

TABLE 1. Feed cost associated with cows supplemented with rBST as related to the cost of Dry Matter per pound.

COST PER POUND OF DRY MATTER	FEED COST PER POUND OF MILK RESPONSE TO rBST ¹
\$0.05	\$0.020
\$0.06	\$0.024
\$0.07	\$0.028
\$0.08	\$0.032
\$0.09	\$0.036
\$0.10	\$0.040
\$0.11	\$0.044
\$0.12	\$0.048

¹ Calculations based on .31 Mcals per pound of milk above maintenance and a ration containing .78 Mcals per pound.

ter per pound of milk response, or 3.97 pounds of dry matter per 10 pounds of milk.

Table 1 on the opposite page lists the feed costs required to produce an additional pound of milk at different costs per pound of dry matter (5¢-12¢). Feed costs in Table 1 are based on .31 Mcals per pound of milk above maintenance and a ration containing .78 Mcals per pound of dry matter. In Table 2 we have calculated the daily feed cost associated with supplementing cows with rBST at different response levels (4-15 lbs). Using a combination of the information on Table 1 and 2 a producer can determine the additional feed cost associated with supplementing cows with rBST at different levels of production.

Labor

Dairy producers will need to reallocate existing labor and/or hire more labor in order to effectively implement an rBST program. Additional labor will be used to keep injection records, inject cows, and body condition score cows. The rBST program can be as simple or complex as desired. The labor cost of an rBST program will likely vary significantly from farm to farm. For example, some dairy producers will keep injection records and body condition score individual cows. Other producers will assign cows to pens which the entire pen will be supplemented with rBST every 14 days.

In this paper, we injected all eligible cows every 14 days starting at 67 days post-partum. We also

TABLE 2. Daily feed cost per cow associated with cows supplemented with rBST at different milk responses.

RESPONSE	FEED COST PER POUND OF RESPONSE			
	\$.020	\$.025	\$.030	\$.035
4	8.0	10.0	12.0	14.0
5	10.0	12.5	15.0	17.5
6	12.0	15.0	18.0	21.0
7	14.0	17.5	21.0	24.5
8	16.0	20.0	24.0	28.0
9	18.0	22.5	27.0	31.5
10	20.0	25.0	30.0	35.0
11	22.0	27.5	33.0	38.5
12	24.0	30.0	36.0	42.0
13	26.0	32.5	39.0	45.5
14	28.0	35.0	42.0	49.0
15	30.0	37.5	45.0	52.5

assumed an additional labor cost of 2¢ per treated cow per day.

Price Of rBST

The price of Posilac is currently \$5.80 per dose. The actual cost of using Posilac, however, will vary by state due to differences in sales taxes. In this paper we assumed a sales tax of 7.25%. That would raise the cost of Posilac to \$6.22 per dose, or 44¢ per day of treatment.

Profitability On A Per Cow Basis

Milk response to rBST and the market price of milk will have dramatic effects on the profitability of using rBST. The profitability of using supplemental rBST on a per cow basis is evaluated in Table 3. We used 12 milk response levels (4-15 pounds) and six mailbox milk price levels (\$9-\$14)¹. The costs of Posilac and labor remained constant in the analysis. Feed cost, however, increased with the level of milk response.

The mailbox milk price will have a significant effect on profitability at a given level of milk response to rBST use. For example, a \$9 milk price

at a 10 lbs. milk response generates a profit of 12¢ per treated cow. That compares to a 42¢ profit per treated cow at a \$12 milk price at the same milk response level.

On the other hand, the level of milk response to rBST use is also extremely important in effectively using this new technology. If we assume a constant milk price of \$10 per cwt, an 8 lbs. response to rBST will generate a 15¢ per treated cow profit compared to a 35¢ per treated cow profit from a 12 lbs. response.

Financial Implications Of Using rBST In Dairy Herds Milking 2 Times And 3 Times Per Day

In this section we will analyze the profitability of rBST in a representative Western dairy herd. One issue that will be explored is whether it is more profitable to use rBST with twice a day (2X) milking and three times per day (3X) milking. While 3X milking results in a production increase, 2X milking allows

¹: Net milk price paid to producer

TABLE 3. Profitability per cow supplemented with rBST per day by milk response and milk price.

RESPONSE LBS.	EXPENSES ²				MAILBOX MILK PRICE ^{1,3}													
					\$9.00		\$10.00		\$11.00		\$12.00							
	POSILAC	FEED	LABOR	TTL COST	CWT LB.	INCOME	PROFIT	CWT LB.	INCOME	PROFIT	CWT LB.	INCOME	PROFIT	CWT LB.	INCOME	PROFIT		
4	\$0.44	\$0.13	\$0.02	\$0.59	\$0.36	(\$0.23)	\$0.40	(\$0.19)	\$0.44	(\$0.15)	\$0.48	(\$0.11)	\$0.52	(\$0.07)	\$0.56	(\$0.03)	\$0.60	\$0.01
5	\$0.44	\$0.16	\$0.02	\$0.62	\$0.45	(\$0.17)	\$0.50	(\$0.12)	\$0.55	(\$0.07)	\$0.60	(\$0.02)	\$0.65	(\$0.03)	\$0.70	(\$0.01)	\$0.75	\$0.04
6	\$0.44	\$0.19	\$0.02	\$0.65	\$0.54	(\$0.12)	\$0.60	(\$0.06)	\$0.66	\$0.00	\$0.72	\$0.06	\$0.78	\$0.12	\$0.84	\$0.16	\$0.90	\$0.16
7	\$0.44	\$0.22	\$0.02	\$0.68	\$0.63	(\$0.06)	\$0.70	\$0.01	\$0.77	\$0.08	\$0.84	\$0.16	\$0.90	\$0.22	\$1.00	\$0.32	\$1.10	\$0.32
8	\$0.44	\$0.26	\$0.02	\$0.72	\$0.72	(\$0.00)	\$0.80	\$0.08	\$0.88	\$0.16	\$0.96	\$0.24	\$1.04	\$0.32	\$1.12	\$0.40	\$1.20	\$0.48
9	\$0.44	\$0.29	\$0.02	\$0.75	\$0.81	\$0.06	\$0.90	\$0.15	\$0.99	\$0.24	\$1.08	\$0.32	\$1.17	\$0.40	\$1.26	\$0.48	\$1.35	\$0.56
10	\$0.44	\$0.32	\$0.02	\$0.78	\$0.90	\$0.12	\$1.00	\$0.22	\$1.10	\$0.32	\$1.20	\$0.48	\$1.30	\$0.52	\$1.40	\$0.60	\$1.50	\$0.72
11	\$0.44	\$0.35	\$0.02	\$0.82	\$0.99	\$0.17	\$1.10	\$0.28	\$1.21	\$0.39	\$1.32	\$0.52	\$1.43	\$0.63	\$1.54	\$0.75	\$1.65	\$0.84
12	\$0.44	\$0.38	\$0.02	\$0.85	\$1.08	\$0.23	\$1.20	\$0.35	\$1.32	\$0.47	\$1.44	\$0.60	\$1.56	\$0.75	\$1.68	\$0.90	\$1.80	\$0.96
13	\$0.44	\$0.42	\$0.02	\$0.88	\$1.17	\$0.29	\$1.30	\$0.42	\$1.43	\$0.55	\$1.56	\$0.75	\$1.68	\$0.90	\$1.80	\$1.00	\$1.92	\$1.12
14	\$0.44	\$0.45	\$0.02	\$0.91	\$1.26	\$0.35	\$1.40	\$0.49	\$1.54	\$0.63	\$1.68	\$0.90	\$1.80	\$1.00	\$1.92	\$1.12	\$2.04	\$1.28
15	\$0.44	\$0.48	\$0.02	\$0.94	\$1.35	\$0.41	\$1.50	\$0.56	\$1.65	\$0.71	\$1.80	\$1.00	\$1.92	\$1.12	\$2.04	\$1.28	\$2.16	\$1.44

¹ Cost of rBST is \$5.80 per 14 day dose with 7.25% sales tax.
² Feed to milk ratio: Calculations based on .31 Mcals per pound of milk above maintenance, ration containing .78 Mcals per pound of dry matter. At a cost of \$.08 per pound of dry matter.
³ Information developed by Posilac Profitability Estimator, Dr. John F. Smith, NMSU Box 3AE, Las Cruces, NM 88003

more total cows to be milked through the parlor. This analysis will take place using a dairy financial simulation model called Commercial Agriculture Dairy Simulation Model (CADSIM).

The Model (CADSIM)

The CADSIM model was developed by the University of Missouri Extension to help dairy producers evaluate the financial implications of expansion or management changes. The model is a whole-farm financial planning tool that incorporates a detailed dairy enterprise with an ability to project financial statements over a 5-year planning horizon. The model consists of five interactive modules: Production, Feed, Labor, Loan, and Expense. These modules are then used to calculate financial statements and measures that lenders and/or investors will need to evaluate a loan or investment package.

The model simulates production and financial information over a 5-year period. A dairy enterprise budget is then estimated from a simple average of the financial information in the profit/loss statement over the 5-year period.

\$12.00	CWT	\$13.00	CWT	\$14.00
\$0.12	LB.	\$0.13	LB.	\$0.14
PROFIT	INCOME	PROFIT	INCOME	PROFIT
(\$0.11)	\$0.52	(\$0.07)	\$0.56	(\$0.03)
(\$0.02)	\$0.65	\$0.03	\$0.70	\$0.08
\$0.06	\$0.78	\$0.12	\$0.84	\$0.18
\$0.15	\$0.91	\$0.22	\$0.98	\$0.29
\$0.24	\$1.04	\$0.32	\$1.12	\$0.40
\$0.33	\$1.17	\$0.42	\$1.26	\$0.51
\$0.42	\$1.30	\$0.52	\$1.40	\$0.62
\$0.50	\$1.43	\$0.61	\$1.54	\$0.72
\$0.59	\$1.56	\$0.71	\$1.68	\$0.83
\$0.68	\$1.69	\$0.81	\$1.82	\$0.94
\$0.77	\$1.82	\$0.91	\$1.96	\$1.05
\$0.86	\$1.95	\$1.01	\$2.10	\$1.16

Assumptions Used In The Model

The profitability of rBST use was evaluated by simulating the profitability of a representative Western dairy operation. This was accomplished by entering production, expense, and financial data into the CADSIM model in order to develop a baseline. The data used for this exercise was provided by the accounting firm of Genske, Mulder & Company.¹

We assumed a herd size of 1,170 cows (milking and dry) that would milk 3X with daily average production of 66.1 lbs. per cow with no BST. That would translate into a 365-day rolling herd average of 20,470 lbs. The following were also assumed:

- \$12.50 gross milk price
- 13-month calving interval
- 60-day dry period
- 29% cull rate
- 2% death rate
- 3% of milk not shipped

Two rations were fed for milking cows: a 2 week start-up ration (cost of \$3.24 per day) and a high production ration (\$3.73 per day) for the balance of the days in milk.

Labor was calculated based on time spent milking, feeding, and other chores. Annual milking labor was calculated based on 3X milking, 1 hour per shift cleanup and setup, and throughput of 160 cows per hour (assumes a double-20 parallel parlor). Total annual labor was calculated as follows:

- 23,662 hours for milking
- 5,265 hours for feeding and other chores
- \$202,486 hired labor bill
- \$40,000 for salaried herdsman
- \$14,549 total company benefits

The baseline is presented in the first three columns of table 4. Notice that the baseline indicates a total herd profit of \$130,895, which is \$112 per cow and 55¢ per hundredweight of milk sold. This scenario is called the baseline and all other scenarios discussed below are compared to it.

¹: The authors wish to thank Wayne Cunningham for his assistance.

Using rBST

Use of supplemental rBST is considered in order to improve overall farm profits. The following assumptions are made regarding use of rBST:

1. All eligible cows receive rBST supplementation according to label.
2. Supplementation begins at day 67, with a 10 lbs. per day response.
3. rBST costs of \$5.80 per 14-day dose, with a

7.25% sales tax.

4. Cows supplemented with rBST for 268 days.
5. Annual feed cost per cow increased by \$74 per cow.
6. Labor hours per cow increased by 0.71.

The financial implications of rBST use on the representative farm is presented in columns 4-6 in table 4. Use of rBST improves total milk production and production per cow. Feed costs for the herd and per

Table 4. Net Income for the Dairy Enterprise milking 3X With and Without rBST

	Without rBST ¹			With rBST ²		
	Herd	Per Cow	Per CWT	Herd	Per Cow	Per CWT
INCOME FROM OPERATIONS:						
Milk sales	2,992,514	2,558	12.50	3,353,361	2,866	12.50
Calf sales	84,389	72	0.35	84,389	72	0.31
Total gross receipts	3,076,903	2,630	12.85	3,437,749	2,938	12.81
OPERATING EXPENSES:						
Feed:						
Concentrates	825,076	705	3.45	873,204	746	3.25
Forages	687,153	587	2.87	726,044	621	2.71
Total feed	1,512,229	1,293	6.32	1,599,251	1,367	5.96
Herd replacement costs						
Depreciation--dairy cows	164,768	141	0.69	164,768	141	0.61
Loss on sale of cows	92,621	79	0.39	92,621	79	0.35
Total herd replacement costs	257,389	220	1.08	257,389	220	0.96
Labor (includes SS & Medicare)	272,027	233	1.14	278,531	238	1.04
Marketing ³	218,272	187	0.91	244,592	209	0.91
BST cost	0	0	0.00	125,925	108	0.47
Interest	191,300	164	0.80	191,300	164	0.71
Depreciation--not cows	57,367	49	0.24	57,367	49	0.21
Other Operating costs	439,210	374	1.83	487,023	415	1.83
TOTAL OPERATING EXPENSES	2,946,008	2,518	12.31	3,248,613	2,769	12.08
NET INCOME FROM OPERATIONS	130,895	112	0.55	197,676	169	0.74

¹Total herd size of 1,170 cows (milking and dry) with average daily milk production of 66.1 pounds per day in year 1.

²Total herd size of 1,170 cows (milking and dry) with average daily milk production of 74.1 pounds per day in year 1.

³Includes milk hauling, State and Federal promotion, and coop/marketing fees.

cow increase due to greater feed intake. Labor costs for the herd increased \$6,504 over the baseline when rBST was used. An additional .71 hours of labor was used per cow per year to manage the rBST program. Labor costs on a per cwt. basis, however, decline due to greater milk production levels. Marketing costs (for hauling, federal assessments, and capital retains) increases for the herd and per cow due to greater milk production levels. The cost of

the rBST is estimated at \$108 per cow per year, or 47¢/cwt. Most other costs remain the same on a per herd and per cow basis, but fall on a per cwt. basis due to greater milk production. Overall net farm profits increased by \$66,781 from rBST use, or by \$57 per cow and 19¢/cwt. of milk sold.

Switching Back To 2X Milking

Use of rBST has allowed many producers to retain cows in the milk string that would otherwise have

Table 5. Net Income for the Dairy Enterprise milking 2X With and Without rBST

	Without rBST ¹			With rBST ²		
	Herd	Per Cow	Per CWT	Herd	Per Cow	Per CWT
INCOME FROM OPERATIONS.						
Milk sales	4,000,361	2,256	12.50	4,547,206	2,564	12.50
Calf sales	127,899	72	0.40	127,899	72	0.35
Total gross receipts	4,128,260	2,328	12.90	4,675,159	2,636	12.85
OPERATING EXPENSES:						
Feed:						
Concentrates	1,196,599	675	3.74	1,269,547	716	3.49
Forages	997,990	563	3.12	1,056,934	596	2.91
Total feed	2,194,590	1,238	6.86	2,326,480	1,312	6.40
Herd replacement costs:						
Depreciation--dairy cows	323,617	182	1.01	323,617	182	0.89
Loss on sale of cows	95,422	54	0.30	95,422	54	0.26
Total herd replacement costs	419,040	236	1.31	419,040	236	1.15
Labor (includes SS & Medicare)	297,189	168	0.93	307,047	173	0.84
Marketing ³	291,784	165	0.91	331,675	187	0.91
BST cost	0	0	0.00	190,852	108	0.52
Interest	250,397	141	0.78	250,397	141	0.69
Depreciation--not cows	57,367	32	0.18	57,367	32	0.16
Other Operating costs	591,568	333	1.85	664,037	375	1.84
TOTAL OPERATING EXPENSES	4,100,016	2,312	12.81	4,545,704	2,563	12.50
NET INCOME FROM OPERATIONS	28,244	16	0.09	129,456	73	0.36

¹Total herd size of 1,773 cows (milking and dry) with average daily milk production of 58.3 pounds per day in year 1.

²Total herd size of 1,773 cows (milking and dry) with average daily milk production of 66.3 pounds per day in year 1.

³Includes milk hauling, State and Federal promotion, and coop/marketing fees.

been culled for low milk production without rBST use. This change has resulted in lower cull rates and an increase in herd sizes. In order to milk more cows in a 24-hour period without expanding the parlor, the decision could be made to switch from 3X milking back to 2X milking. But is this move profitable?

To evaluate this, one must first consider what happens to profitability when switching from 3X without rBST use to 2X without rBST. The following assumptions are made:

- Switch from 3X to 2X milking.
- Lower cow throughput from 160 to 150 cows per hour (due to more milk per milking).
- Lower the herd lactation curve by 10%.
- Lower the cull rate to 19% in year 1 and 25% in year 2.
- Purchase 976 cows in year 1 to increase herd size to 1,773 cows.
- Reduce ration costs by 5% per day.

The herd size was increased in order to keep the parlor milking 22 hours per day. Daily milk production was reduced in order to reflect the switch from 3X to 2X milking. The financial results are presented in columns 1-3 in table 5. They indicate that switching from 3X milking without rBST use to 2X milking without rBST use will lower annual profits by \$102,651 or by \$96 per cow. While gross income for the herd increases under 2X milking, per cow income declines due to lower milk production per cow. Total feed costs increase due to more cows, but declines on a per cow basis due to lower nutritional demands. Total interests costs increase due to debt on purchased cows. Likewise, all other costs increase on a herd basis, but decrease slightly on a per cow basis due to more cows to spread these cost

Ranking The Results:

1. The most profitable scenario is rBST use with 3X milking.
2. The least profitable scenario is 2X milking without rBST use.
3. The difference in total profits between these two extremes is \$169,432.
4. Total profit for the 2X scenario with rBST use is comparable to herd profits for the 3X scenario without rBST use.
5. There is no gain in profits from switching from 3X without rBST to 2X with rBST.
6. Milking 2X is less profitable than milking 3X with or without rBST.

over.

What happens if rBST is used with 2X milking? To determine the effect, assumptions were used in the 3X scenario with rBST use. The financial implications of rBST use with 2X milking are presented in columns 4-6 in Table 5. This scenario indicates a \$57 per cow improvement in profits relative to the 2X scenario without rBST.

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Making BST Work: The Producer Experience

Panelists:

Ron St. John, Alliance Dairies, Trenton, FL
Tom Thompson, Stotz Dairy, Buckeye, AZ
Romulo Escobar Valdez, Escobar Dairy, Juarez, Mexico

Moderator:

Ruth Blauwiekel, Extension Dairy Specialist
Washington State University

Bovine somatotropin (BST) was approved for use in the United States in November of 1993, although a Congressional moratorium delayed its release onto the market until February of 1994. In spite of the initial controversy surrounding its use, BST has made significant inroads among dairy producers, particularly in larger herds in the Western states. At the end of 1994, Monsanto estimated that 10-11% of dairy herds in the U.S. were utilizing BST. USDA estimated that as many as 25% of dairy managers would be using BST in their herds by the end of 1995.

Other countries in the western hemisphere that have approved the use of BST in dairy cows include Brazil, Costa Rica, and Mexico. Mexican dairy producers have had access to BST since October of 1990. This panel discussion brings together the managers of three large dairy herds from the U.S. and Mexico to describe their experiences with this new management technology.

Could you briefly describe your herd?

Romulo Escobar Valdez: "In 1983, the Escobar Dairy began an expansion program with new facilities and 2,000 cows. There are now 4,150 cows on a drylot dairy, with 3,680 milking. On the dairy are also about 300 close-up heifers. About 2,500 replacements are on a separate farm, along with 500 bulls being raised for beef. The cows are managed in four separate units, each with its own 24-cow Bou-Matic polygon. Alfalfa, and sorghum and rye-grass for silage are grown under irrigation on 1,750 acres. Between 130 and 140 workers are employed at the farm."

(Note: The dairy uses a consulting nutritionist, a veterinarian, and an equipment specialist. Current herd average is 24,240 lbs. of milk on 3X milking, the highest producing herd in Mexico. Romulo is owner and manager of the dairy.)

Ron St. John: Ron is managing partner of Alliance Dairies, a 2,800-cow Florida dairy located 60 miles south of the Georgia state line. The dairy also raises 2,000 head of young stock and about half of its own

forages in order to utilize manure generated by the farm, growing corn, millet and rye for silage. There are 44 employees. The dairy employs a consulting nutritionist and also a veterinarian who is both a consultant and a 'hands-on' practitioner. Rolling herd average is 21,000 lbs. on 3X milking.

Tom Thompson: Tom is managing partner of Stotz Dairy, a 1,400-cow dairy in Buckeye, Arizona. The farm raises all its own replacements and has 1,500 head of young stock. There are 17 employees. The farm hires a nutritionist to formulate rations and has a veterinarian do fertility work at three-week intervals. The climate is hot and arid and cows are housed in drylot corrals. Milking is done 3X in a 34-stall polygon. Land base is 1,200 acres, some of which is used to grow corn silage, oatlage, barley and alfalfa for the dairy. Stotz Dairy has had the top DHIA rolling herd average in Arizona for 8 of the past 10 years; current herd average is 26,423 lb of 3.5% FCM.

How long have you been using BST?

Escobar: Escobar Dairy began using BST in October of 1990. We were the first commercial dairy in Mexico to use the product. We began by running our own trial, with 70 control and 70 BST-treated cows in a single pen. On that initial group of cows, we had a 15.3 lbs. increase in milk production. Then we began to use BST at 160 DIM (days in milk) on all bred cows with a body condition score of 3.5. Now, we begin BST injections on all healthy cows at 100 DIM, with condition scores of 3.0 or higher, without regard to reproductive status.

St. John: Alliance Dairies began using BST about two weeks after FDA approval was granted. We are associated with two other dairies, one of which was a trial herd, and we were convinced that Alliance Dairy would benefit from utilization. Forty percent of the herd was treated initially. The use of BST was approached conservatively because of concern over possible increased twinning rate. Presently, BST is used on all cows beginning at 120 DIM, except cows slated for culling, who begin receiving BST as soon after calving as they begin regaining body condition. Injections are given in lockups.

Thompson: A trial with the Monsanto product was conducted on Stotz dairy (100 injected and 100 control cows) during the summer of 1989. The objective was to determine if a response would be seen in heat-stressed cows, who at that time were being milked 4 times per day. We postponed using BST after FDA approval until mid-April, out of deference to our milk co-op which had asked producers to observe an extended moratorium. Initially, we gave cows BST if they were greater than 100 DIM, except for any cows who had disease problems or were slow milkers. Now, we start cows at 60 DIM as long as their body condition score is 2.75 or higher. By 100 DIM, nearly all cows are being injected.

What milk production response have you seen with the use of BST? How was that response monitored?

Escobar: As I said, we demonstrated a response of 15.3 lb (7 kg) in our initial farm trial. Since then we have not made an effort to track individual cow response to BST. Many things affect milk production, especially weather and feed quality. However, our herd average has increased from 19,820 lbs. to 24,240 lbs. since October of 1990.

St. John: With 40% of the herd treated initially, we saw an increase of 4 lbs./day in bulk tank milk, indicating a 10-lbs. response in treated cows. It's difficult to evaluate the milk production response on a bulk tank or even an individual cow basis because of so many variables. This year we are actually shipping less milk than at the same time last year, but this fall and winter have been harder on cows because of wet and muddy conditions. We are confident that we are getting a response because of the increase in bulk milk that occurs with each injection. Our time is better spent on other aspects of management, such as improving heat detection or cow comfort, than on monitoring response to BST.

Thompson: In the mid-summer trial run by Monsanto we observed an 8.6 lbs. increase in milk (10.8%) with no difference in milk fat or protein; an increase in SCC of 51,000; and no effect on reproduction or metabolic disease incidence. Since this

trial demonstrated that the product was effective on our farm, we don't feel the need to monitor response closely. Individual cow measurements on a day-to-day basis are probably not justifiable economically. When we started BST injections in April of 1994, we had a 7 lbs. increase in bulk milk within one week, with 52% of the herd getting injections. This indicates that injected cows increased milk production by about 13 lbs. We did not observe an increase in bulk tank SCC.

Did you make any changes in the feeding program prior to beginning the use of BST?

Escobar: At the time we began using BST, we made no changes in the feeding program. We were grouping cows into three groups by production. We soon observed that treated cows were losing body condition. The diet already contained whole cottonseed, but we began adding additional tallow and protected fat. We also began incorporating blood meal into the TMR. Since beginning the use of BST, we have had to work harder to keep body condition on the cows. For instance, getting the best quality forage is critical. Because cows are fed in groups, it's difficult to determine how much of an effect BST has had on feed intake. Many other factors affect feed intake; last summer, for example, we had 60 days in a row with temperatures over 100°F. For the same reason, it's difficult to measure the effect on feed costs.

St. John: Initially we made no changes in our feeding program. We feed a TMR to meet cows' appetite. Our nutritionist balances the rations for energy and undegradable protein according to NRC recommendations. We have always included some tallow in our rations. This past summer we also included a bypass fat source because cows' body condition scores were lower than the previous year. We can't really measure any increase in feed consumption and didn't notice any appreciable increase in feed costs with BST use. Obviously, the cows will eat more feed if they're making more milk, but feed intake is affected by a lot of other things (most notably the weather).

Thompson: We increased the energy density of our TMR with additional bypass fat and tallow even before we began using BST. We wanted to increase cows' condition scores so they would have the reserves to respond to the injections. We have increased the undegradable protein in our rations, but that was more in response to our nutritionist's recommendations than because we were using BST. We also switched to a true TMR, with hay blended into the ration rather than fed separately, for the same reason. We observed an increase in feed intake of 4-6% about one week after the 2nd injection, or three weeks into BST supplementation. We calculate that feed costs increased about 35¢ per cow per day, or 43¢ per hundredweight of milk.

Have you noted any injection site problems (swelling or abscesses) with the product? Do cows have a strong aversion to the injections?

Escobar: We haven't had any problems at the injection site, but I feel this is due to careful training of the person giving injections. Our personnel haven't noted any changes in the cows' behavior.

St. John: We haven't noted any significant injection site problems. However, the cows seem to anticipate the injections. For some reason when you strap on that red pouch, some cows become real idiots.

Thompson: We hadn't noted any injection site problems until the veterinarian TB-tested the herd. Some cows had swellings which might have been interpreted as positive TB tests if we hadn't noted them beforehand. We have had to train the person who does the injections to be sure that the cow gets the entire dose and that it goes in the right location. The cows that are being injected tend to be apprehensive when they are approached by a person they associate with needles. The vet knows which cows are being injected.

Have you noted any changes in reproductive performance since beginning the use of BST?

Escobar: We found that we had to increase the intensity of our reproductive management, particularly heat detection. We began routinely chalking tailheads at that time. Once we made adjustments in the rations, reproductive performance also improved. We currently begin breeding cows A.I. at 45 DIM, as long as they have healthy reproductive tracts. The cows are bred at least twice to a sire chosen by Holstein's mating program, then we may breed to less expensive sires. We do not use natural service. Calving interval is 13.4 months.

St. John: Calving interval is actually slightly lower now than before we began using BST (presently 13.4 months). However, we wait until 120 DIM before beginning injections, so most cows are already bred. We typically use A.I. for breeding up until 120 DIM and then use clean-up bulls.

Thompson: We have detected no change in reproductive performance at all and have made no changes in our reproductive management. Our average DIM at first breeding is 92 days. Our calving interval is 13.5 months and we feel this is the most economical at this level of production. Cows are bred A.I. until we decide on an individual cow basis that it's time to use a clean-up bull. Treat every cow as if she's your only cow and you'll be profitable. On the other hand, our days open have actually increased because cows who are identified as culls are remaining profitable and are staying around longer.

In your opinion, did the use of BST make heat stress management more difficult?

Escobar: We have not noted that heat stress affects the cows' response to BST. However, because feed intake is hurt by hot weather, it is more difficult to keep body condition on the cows during the summer. We have found that we need to pay more attention to cows' body condition with the use of BST.

St. John: In the trial herd that I was associated with, we saw an 18% increase in milk production with BST in spite of high temperatures. I don't believe that BST increases a cow's susceptibility to heat stress any more than high milk production does. We

have what we consider "state of the art" facilities for minimizing heat stress: misters under pressure, sprinklers, shade and fans. Cow comfort is very important to us, whether we're using BST or not.

Thompson: We already had an extensive cooling system in place at the time we began using BST. We have a herd of high-producing cows and we want them to continue producing at high levels, regardless of weather conditions. That situation didn't change with the addition of BST to our management system.

In addition to the labor required for injections, have you tracked any other labor costs which might be attributed to the use of BST?

Escobar: We have not incurred any increase in labor costs due to the injections. The cows are injected in lock-ups and we do a group of cows each day. The cows are body condition scored with each "event", such as calving, fresh cow exam, and BST injection. We are basically doing the job with the same people as before BST. The same is true of feeding and milking.

St. John: The labor required to inject 1,000 cows is 22.5 hours (or 45 hrs./month) including the time to assemble syringes. There haven't been any measurable effects on labor necessary for milking or feeding; we milk 24 hours/day anyway and the milkers complete milking on schedule.

Thompson: One person does all the injections in 6 hours (about 800 cows). A separate person identifies cows to be injected. We put neckchains on cows at freshening and take them off when it's time to begin injections. Labor costs about 2¢ per cow per day to both identify cows and inject them. This does not include assembling the syringes, which

requires a significant amount of time. We haven't noted any significant increase in labor costs. Even the time to do the injections has been made by re-allocating other jobs. Time for milking and feeding is not really different.

What other observations have you made relative to the use of BST that would be of interest to other dairy producers?

Escobar: In many ways, using BST is like changing from 2X to 3X milking. It's important that you are managing the cows well before using BST, because management will be more difficult afterwards. Try to anticipate problems, like loss of body condition in cows or difficulty in detecting heats. Attention to detail, such as forage quality and cow comfort, will be even more critical when using this technology.

St. John: If you look around the country, you see that the producers who are successful are those who produce at the lowest cost. BST is a tool that can be used to cut the costs of producing milk. We can demonstrate that BST has made a significant difference in our bottom line.

Thompson: The trick to using BST successfully is to reduce stress on the cows, to have everything else right first. You have to be able to manage body condition so that cows will maintain response from year to year. The real fallout from the use of BST will show up in the second year if cows aren't fed properly. You need to make use of competent consultants who are committed to your success. The beauty of this management tool is that it can be turned on and off if milk or feed prices make it uneconomical.

notes

Footwarts In Dairy Cattle: Current Understanding Of A Complex Disease

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During the last 7-8 years, footwarts has emerged as a serious cause of lameness in cattle in the Western United States. Reports in the scientific literature reveal that footwarts occurs worldwide and has been known to have existed for more than 20 years. The first published report on footwarts was by Drs. Cheli and Mortellaro in Italy in 1972. Additional reports from several other European countries soon followed. Footwarts has also been described in Israel, Iran, Japan, Mexico and South America. This disease has been recognized in the United States for at least 15 years, with out-

major problem for dairies in other Western states. It is extremely unlikely that a footwart problem of the magnitude that exists today would have gone unrecognized for any appreciable length of time, indicating that this truly is an emerging problem. It is possible, however, that footwarts have been present

Footwarts has gone from being an occasional nuisance to a substantial economic and health problem in dairy cattle worldwide.



Figure 1: Lame cow with footwart on back leg

in the Western United States for some time but at a much lower incidence. Indeed, some hooftrimmers report seeing foot conditions identical to today's footwarts on California dairies as long as 25 years ago. This scenario would suggest that something has changed in the last 7-8 years to account for the dramatic increase in the

incidence of footwarts.

breaks on New York dairies reported as early as the late-1970s.

It is unclear when the problem with footwarts first occurred in the Western United States. Reports from dairy managers and hooftrimmers in California suggest that footwarts only recently became a significant problem in California and that prior to the late 1980s they were an insignificant problem or nonexistent. A recent survey of California dairies revealed that, today, approximately 75% of the dairies in southern and central California have experienced footwart problems. It also was estimated that approximately 8% of the cattle in these areas had footwarts during 1993. Footwarts has also become a

One of the most perplexing questions is the worldwide increase of this disease in the last few years. Although footwarts has been recognized in some parts of the world for more than 20 years, it seems that the same dramatic increase we are experiencing in the Western United States is happening worldwide. The increasing importance of the footwart problem was evidenced by the amount of attention it received at the most recent International Symposium on Disorders of the Ruminant Digit held in Banff, Canada, in June 1994. Footwarts has gone from being an occasional nuisance to a substantial economic and health problem in dairy cattle worldwide. Given the various breeds of cattle,

genetic differences, environmental conditions, nutritional factors and variations in overall dairy management practiced worldwide, it is hard to believe that a common event has occurred on a global basis to account for the worldwide increase in the incidence of this disease.

To fully understand the footwarts problem and develop appropriate control or prevention strategies, a clear definition of footwarts and differentiation from similar conditions is paramount. Footwarts is a superficial skin disease of cattle, which for the most part is limited to the area below, or at, the pastern. It involves predominantly the epidermal layer of skin with a lesser involvement of the dermal layer. The name footwarts became popular because of the superficial resemblance to true bovine viral warts. The majority of footwarts are located on the back of the foot between the bulbs of the heel and often involve the interdigital ridge. Less frequently, footwarts can be found on the plantar pastern, at the front of the foot or extending into the interdigital space. In some dairy cows the front of the foot seems



Figure 2: Early to intermediate stage footwart.



Figure 3: Mature footwart with hair-like structures.

be a frequently affected site. Generally, the back feet are affected more frequently than the front feet. More than one foot can be affected at a time and occasionally multiple footwarts can be found on one foot.

The appearance of a footwart can be quite variable. Early footwarts tend to be flat, circular and have a fairly well-delineated border. Some footwarts are oval or U-shaped. They may be gray-to-red in color, appear moist and bleed easily when manipulated. As the lesion becomes more chronic, the footwart tends to become more proliferative in nature and may develop small, hair-like structures or fronds. These hair-like structures, in fact, represent abnormal skin growth. At the edge of some footwarts, true hairs can become quite long. The more mature form of footwarts is often elevated and can be golf-ball to tennis-ball size. They may or may not have these long hair-like structures. The mature forms with the hair-like structures account for the commonly used term "hairy footwarts."

Confusing terms for footwarts, and an incomplete understanding of the various ways that footwarts can present, has led to a great deal of confusion about footwarts. There are many lay and scientific terms that have been applied to this disease, which attest to the confusion that has existed. Lay terms such as hairy footwarts, strawberry heel, raspberry heel and heel warts, in fact, all refer to the same condition. In the scientific literature, the number of terms used to describe the same disease has been just as confusing with names like interdigital papillomatosis, digital dermatitis, and verrucous dermatitis and papillomatous digital dermatitis all being used for the same disease. In the past, some of these terms were used to describe what were believed to be entirely different conditions. We now know that these different terms merely describe different stages, or presentations, of the same condition. At the recent meeting of international workers on disorders of the ruminant digit, many individuals from around the world currently working on footwarts were in attendance. Jointly they were able to help clarify the footwart terminology problem. The meeting also resulted in establishment of an international task force aimed at maximizing dissemination of new information about this disease.

Just as important as recognizing what constitutes a footwart is the ability to recognize what a footwart is "not." Numerous other foot conditions that can affect cattle must be differentiated from true footwarts. Footrot is a common foot condition that can be differentiated readily from footwarts by the presence of swelling of the foot and separation of the toes. These signs are not present in uncomplicated cases of footwarts. Sole ulcers, pastern ulcers, laminitis, white line disease, fibromas (corns), heel erosions and interdigital dermatitis are other foot conditions that may also be encountered. Close examination of the foot is necessary to identify and differentiate the many foot conditions of cattle. As our knowledge about footwarts has increased, the full spectrum of ways in which footwarts can present continues to expand. Some researchers have independently suggested that interdigital dermatitis may,

in fact, be another manifestation of footwarts, differing only by the location of the lesion. Therefore, when trying to assess accurately the seriousness of footwarts disease on a dairy, it is important that all possible causes of lameness be considered. Keep in mind that two or more foot problems may exist on a dairy at any one time and that an individual cow may have two or more foot-related problems simultaneously.

Usually, the first sign that brings one's attention to the possibility of footwarts is an increased number of lame cows. On some dairies, it is predominantly the heifers that are affected; others report a more even distribution of ages affected. Although, footwarts can cause moderate-to-severe lameness, not all cattle affected with footwarts have detectable lameness. In some cases, an abnormal stance may be the only sign exhibited. We have visited some dairies where the dairy owners and managers have stated, with certainty, that no problem with footwarts existed. However, upon examination of the feet of cows as they passed through the milking parlor, footwarts were found. This illustrates how the problem can be present, but missed, when only a limited number of cows are affected or if the lameness is subtle in nature. Lameness should not be used as the sole criteria for determining if footwarts exist on any particular dairy. To properly determine if a dairy has a footwart problem the feet of sound cows, as well as lame cows, should be examined. If hooftrimmers are employed for routine hoof maintenance, they can serve as an ideal source for accurately assessing footwarts and the magnitude of the problem.

The severity of a footwart problem on a dairy can be quite variable. On some dairies, only a small number of animals are affected. Under these circumstances, the situation does not present a serious health or economic problem. Other dairies experience explosive outbreaks with numerous animals affected over a short period of time. Still other dairies may experience persistent problems with a substantial number of cattle affected at any one time. In the last two scenarios, the economic impact can

be quite substantial. Lameness can cause weight loss, decreased milk production and decreased fertility. Understanding the factors on the dairy, that may predispose to the development of footwarts are critical in developing programs to control the numbers of cases of footwarts, thereby minimizing the economic impact.

A main goal of the Footwart Task Force at the School of Veterinary Medicine at the University of California, Davis is to identify factors important in the control of footwarts. Most information about potential factors associated with footwarts is based on individual impressions; few controlled studies have been conducted. With funding support from the California Dairy Foods Research Center and the UCD School of Veterinary Medicine Livestock Disease Research Laboratory, the task force is trying to establish the environmental factors that predispose dairy cows to developing footwarts and the differences that account for one dairy having severe footwart problems while others only have occasional problems. Some preliminary findings from a study conducted by Dr. David Hird indicate that the combination of wet and warm weather predispose to serious footwarts problems. In southern California, although footwarts can be a year-round problem, most cases occur in late spring and early summer when fair amount of moisture is present and the temperature is rising. The muddiness of corrals has also been found to be a important factor and may be a reflection of overall corral management rather than just degree of muddiness. Other factors such as abrasiveness of the footing surface and confinement are also likely to be important. Dairies that maintain cows on pastures, rather than in dry lots or freestalls seem to have lesser problems with footwarts.

The exact cause of footwarts remains a mystery. Most researchers believe it is multifactorial in nature and that all factors must be in place for the disease to develop. Footwarts can rapidly spread on a dairy once it is introduced which suggests that an infectious component is involved. Initially it was believed that viruses play a role because of superficial similarities of footwarts to true bovine warts, which are

caused by a papilloma virus. Searches for possible viral agents have been conducted by several individuals using a variety of techniques, including electron microscopy, immunoperoxidase tests and DNA probes. All of these studies have failed to detect viruses associated with footwarts.

The observation that footwart lesions often resolve, or greatly decrease in size, when antibiotics are given by injection, without manipulation of the footwart itself, was essential in identifying an important factor. Since antibiotics are active only against bacteria, and not viruses, the response of footwart lesions to antibiotics strongly suggests that bacteria play a important role in the disease. The same results are also obtained when antibiotics are applied topically to the footwarts itself, especially if the lesions are in the early stages. In these cases, pain and lameness often disappears within 24-48 hours. It is unclear whether the role that the bacteria play is a primary role or whether it is only after some other initiating factor(s) that bacteria become important.



Figure 4: Footwart prior to treatment with injectable antibiotic.



Figure 5: Footwart after treatment with injectable antibiotic.

In an experimental trial that we conducted, material from active footwart lesions was applied to the feet of unaffected cattle. No footwarts developed. Even the presence of skin abrasions did not lead to the development of footwarts. These findings suggest that mere exposure to footwart material and the associated bacteria is insufficient to cause footwarts. This finding supports the suspicion that other factors must also be present for footwarts to develop. It is hoped that studies to identify factors on dairies with severe footwart problems will provide clues.

Since bacteria do appear to play an important role in the disease process, the task force has been attempting to determine which bacteria are associated with footwarts and which bacteria may be important in the disease process. The environment in which cattle spend most of their time obviously lends itself to exposure to numerous types of bacteria. The main problem is to determine which of these bacteria are important. Using a special staining technique, Dr. Deryck Read showed that a large number of spiral-shaped bacteria could be found fairly deep in the footwarts. These particular bacteria, called spirochetes, have been a focus of the task

force. Our first goal has been to isolate them in the laboratory. Once isolated, a criteria for classifying them must be developed. To date, we have isolated two types of spirochetes and are currently studying which one is invasive in the footwarts. It does not appear that either of these bacteria has been isolated previously. We are also conducting a more comprehensive study to identify the other bacteria found in footwarts. This has proved to be difficult, since many of these organisms have never been previously identified.

Based on current knowledge, there are treatment and control measures that can be undertaken for footwarts. Because each dairy is different, it is important that approaches for control and treatment of footwarts be customized to the particular situation. First, it is important to establish that footwarts exist on the dairy and, if present, to establish the magnitude of the disease problem. A biopsy of a lesion is useful for initial confirmation of footwarts.

If a dairy is truly free of footwarts, then efforts to prevent introduction are extremely important. Based on the premise that there is an infectious component to footwarts, and since the specific agents are yet to be identified with certainty, standard biosecurity procedures should be employed. Maintaining a closed herd is the best way to prevent introduction of footwarts. If replacement heifers must be purchased from an outside source, the replacement heifers should be quarantined for at least one month and all feet closely examined for active footwarts before allowing these animals to mix with the herd. Prophylactic treatment, such as footbaths, may also be beneficial for minimizing potential for introduction. Individuals who perform services for the dairy, such as hooftrimmers and veterinarians, should be requested to disinfect boots and equipment prior to working with cows on the dairy.

In infected herds, topical treatments with antibiotics or caustic compounds, applied either in footbaths, by sprays or by footwrap have been shown to be effective in treating footwarts. In a recent controlled clinical trial headed by task force member Dr. Walter Guterbock, topical tetracycline or linco-

mycin/spectinomycin footwraps were shown to be highly effective treatments. Both of these treatments resulted in greater than 92% recovery. Most researchers feel that lincomycin is the active component in the lincomycin/spectinomycin combination. Because lincomycin can be toxic or lethal to cows if taken orally, great care should be taken to ensure that it is not ingested. Intramuscular injections with ceftiofur or topical application of formaldehyde were also effective, but less so than the antibiotic footwrap treatments.

The effectiveness of topical antibiotic treatments is most likely due to the superficial nature of the infection. Since footwarts are superficial in nature, deep penetration of topical antibiotics is not required to be effective. To maximize the effectiveness of topical treatment, lesions must be treated in the early or intermediate stages, and the lesion must be adequately cleaned prior to the antibiotic treatment. Many of the failures reported with antibiotic treatments can be traced back to inadequate foot preparation prior to treatment. Once the footwart becomes mature and proliferative in nature, surgical excision may be required to effect a cure. The entire footwart must be removed rather than just shaving off the top portion of the footwart. Secondary infections can result as a complication from surgical removal of the footwart.

Footbaths have an overall role in maintaining hoof health and can be used in conjunction with other measures to control footwarts. When used as the sole method of treatment, results have been variable and sometimes have been only minimally effective. As with any topical treatment, adequate cleaning of fecal material from the hoof, especially material that may be covering the footwart, is very important prior to using a footbath. To obtain maximum benefit from any footbath, it is also important to maintain footbaths at proper levels to ensure that the entire hoof and pastern area is submerged to adequate level. Regular changing of the footbaths, to minimizing the amount of organic contamination, is also critical.

Documented information on the efficacy of par-

ticular compounds used in footbaths is lacking. Some of the variable responses reported for footbath use are most likely due to lack of attention paid to maintaining proper footbath conditions. A variety of types of footbaths have been used with variable success. Most individuals report that copper sulfate footbaths are not effective in the treatment of footwarts. Copper sulfate with a pH adjustment has been reported to be more effective than copper sulfate alone but not as a sole treatment. Formaldehyde (3-5%) appears to be effective for some individuals, whereas others have reported little or no success. Too strong of a concentration of formaldehyde can cause destruction of healthy hoof tissue or can even lead to sloughing of the hoof. Some individuals also report that the bacterial action of the lagoons slowed noticeably after using formaldehyde in footbaths. In addition, there is concern for worker safety when formaldehyde is used. Preventing accidental exposure to the formaldehyde is important. Tetracycline footbaths have been used by a many individuals and appear to be effective when used properly. Failure when using tetracycline footbaths are probably due to inadequate footbath levels and organic contamination. The use of tetracycline footbaths as a sole treatment appears to be better suited to small, rather than large, dairies. In some cases, footbaths may play a bigger role in prevention and control rather than as an actual treatment for active footwarts.

It is important to be aware that most of the current treatments for footwarts are being used in an "off-label" manner, that is to say that these compounds are not specifically approved for this type of use. It is, therefore, strongly recommended that footwart treatment and control efforts be incorporated in an overall herd health program and that treatment and control efforts be discussed with and monitored by a veterinarian to prevent problems with residues.

The use of vaccines to control footwarts is an area of great interest. Since the exact agent(s) responsible for footwarts still remain to be proven conclusively, it is somewhat premature to consider using vaccines for either prevention or treatment of foot-

warts. Anecdotal information about interdigital dermatitis vaccines to treat or prevent footwarts have been equivocal. Even after the particular agent(s) associated with footwarts have been conclusively identified, there is some question as to how effective a vaccine would actually be. Cows with natural infections do not appear to develop a sustainable immunity to reinfection. The superficial nature of the infection may also complicate development of an effective vaccine.

A great deal of information about footwarts has been learned in a relatively short period of time, in large part due to the cooperation of dairy owners, hooftrimmers and veterinarians. It is apparent that footwarts is a more complex problem than it appears to be on superficial examination. We still have far to go. However, through continuing research efforts, it is hoped that more effective treatment and control measures will be available in the not-too-distant future.

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notes

Colostrals Management: How Good Is Your Program?

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At birth, the baby calf is highly susceptible to disease and has been provided with very meager nutritional reserves. The dam's colostrum specifically provides elements that enhance the calf's disease defenses and supplement other nutritional needs. Therefore, colostrum can be viewed as the single most important nutritional factor for the newborn calf and management practices that enhance the appropriate supplementation of colostrum to newborn calves are critical for increasing calf survival. The focus of this talk will be on factors that influence colostrum quality and colostrum management practices that support the health of the newborn calf.

Immune Defenses Of The Newborn Calf

The mammalian system of defense against invasion by disease-causing organisms has multiple components. Chief among these are:

- 1) humoral immunity, which is provided by circulating and local tissue immunoglobulins;
- 2) cellular immunity provided by certain subsets of lymphocytes;
- 3) other white blood cells including neutrophils and macrophages; and
- 4) other defense proteins including complement, kinin, and other inflammatory proteins. Compared with older animals, the newborn calf is unique because it has not previously encountered disease organisms and its immune system is functional but has not had the "experience" of recognizing specific disease agents. Further, the bovine placenta does not allow the passive transfer of protective immunoglobulins to the calf. As a result, the newborn calf relies on colostrum consumption to prime its immune system with elements made by its more experienced dam.

The aspect of colostrum immune protection that has been most thoroughly described pertains to its content of immunoglobulin. It is clear that colostrum has elements that enhance the other immune functions listed above but the importance and specific actions of these other mechanisms have not been thoroughly researched. Therefore we look at colostrum as providing critically important im-

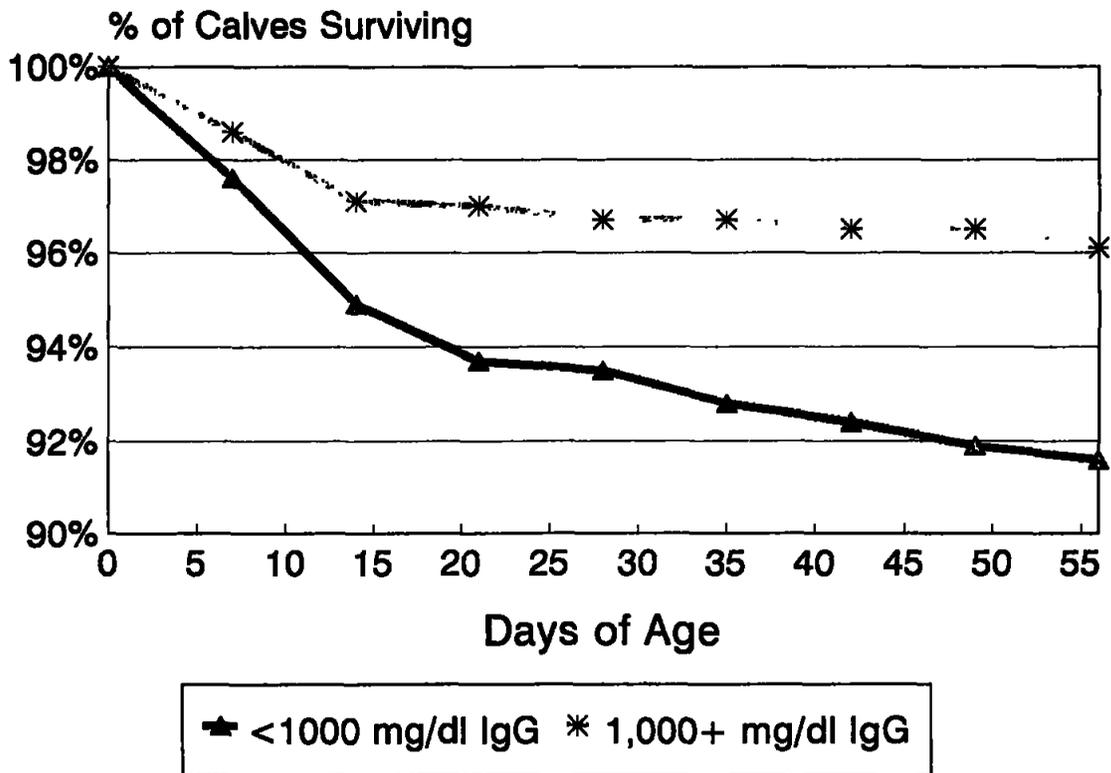
munoglobulin but need to recognize that it does more.

Immunoglobulins (also known as antibodies or gamma globulins) are proteins that the body manufactures to attach to invading organisms and neutralize them. Specific immunoglobulin (Ig) will therefore be manufactured against specific organisms. The process of passive transfer of Ig involves the secretion of Ig by the dam into the colostrum, the consumption of the colostrum by the newborn calf, and subsequently the absorption of the Ig through the intestinal wall and into the calf's circulation. The absorbed immunoglobulins protect the calf against systemic invasion by microorganisms, thus are a critically important aspect of the calf's immune defense system.

It is important to realize that passive immunoglobulin transfer is not a simple "yes" or "no" equation. Acquisition of Ig does not guarantee the calf a disease-free future. To protect the calf against disease, the immunoglobulin has to be present at the right place where the organism is invading, must be present in sufficient quantity to neutralize the agent, and must be of the appropriate immunoglobulin type to attach to the specific invading organism. Whether a calf remains healthy or develops disease will depend on the balance between disease exposure versus disease defenses. As mentioned above, other nonimmunoglobulin defenses are also important for the calf's disease prevention. Nevertheless, a very strong association between passive Ig transfer and calf disease resistance has been shown repeatedly and this process must be seen as the single most important factor that we can manage to enhance calf health.

Because circulating Ig is effective in preventing microorganism invasion, passive Ig transfer is primarily responsible for preventing septicemic bacterial infections. Absorbed immunoglobulin is not nearly as effective at preventing localized enteritis (neonatal calf scours). Agents such as rotavirus, coronavirus, and Cryptosporidia only affect the superficial lining of the gut wall and it appears that circulating Ig has limited efficacy in preventing this type of infection. Numerous studies suggest, however,

National Dairy Heifer Evaluation Project Comparison of Calf Survival Rates by Level of Immunoglobulin (IgG) Concentration



that the severity of diarrhea in enteric disease of neonatal calves and the ability of affected calves to survive is positively influenced by increased circulating Ig. Although passively acquired Ig cannot prevent all calf diseases, virtually all studies of neonatal calf performance show a positive benefit of increased Ig transfer on calf health and survival.

Factors Involved In Passive Transfer

A number of techniques are available for measuring the efficacy of passive Ig transfer to calves. All of these techniques involve the measurement of protein in plasma or serum. Some of these techniques (refractometric protein measurement, zinc sulfate turbidity and sodium sulfite turbidity) are quite inexpensive and can be performed at the farm. Using such measurements, we have developed a good understanding of the factors that positively influence passive Ig transfer.

The two most important factors in passive Ig transfer are the total immunoglobulin mass that is ingested, and the time after birth when the colostrum is received. The immunoglobulin mass is a combination of Ig concentration in the colostrum and the amount of colostrum fed. The product of these two factors is the total immunoglobulin available for absorption by the calf's intestine.

The volume of colostrum produced by a cow is generally not a limiting factor in dairy operations, although it may be a concern in some beef management situations. The volume of colostrum consumed, however, determines the amount available for absorption and this is determined by the amount the calf suckles or is fed. Some producers let the calf suckle the dam, and it might be expected that this would be an efficient method. Although some studies have shown that natural suckling enhances calf

Ig absorption, this method of feeding can also be associated with a significant rate of failure of passive transfer. Factors that contribute to this failure include poor mothering ability by the dam, dam sickness at parturition, poor udder conformation and/or teat structure, and poor calf viability or suckling ability. All of these factors can lead to inadequate voluntary consumption by the calf. It is noteworthy that dairy calves have less vigor and poorer suckling drive than their beef calf counterparts where this method of colostrum consumption is the norm.

Colostrum immunoglobulin concentration can vary tremendously between cows. Older cows generally produce higher quality colostrum than heifers, but there is also wide variation between individuals, even in multiparous cows. The immunoglobulin concentration of colostrum can be estimated by measuring its specific gravity and a commercially available device is available for this purpose. This colostrometer can be valuable in helping select the cows from which colostrum is fed to the newborn calf. Variations in first milking immunoglobulin concentration can easily range from 20-80 mg/ml, or a four-fold difference.

Recommendations for the minimum immunoglobulin mass that a newborn calf should receive are about 100 gm of immunoglobulin. A more appropriate aim would be to provide between 200-300 grams; thus, 4 liters of colostrum at 50 mg/ml would provide 200 gm immunoglobulin to the newborn calf, well in excess of the suggested minimum.

The time at which colostrum is fed to the newborn calf is also very important. It has been well established that immunoglobulins are absorbed from the intestine for only the first 24-36 hours after birth. All studies agree, however, that there is a substantial decline in the capacity of the intestine to absorb Ig throughout this time. The earlier the calf receives an appropriate amount of immunoglobulin, the better the absorption will be. The recommendation must be that colostrum is fed as soon as possible after birth and preferably within the first two hours of life. Delaying the first colostrum feeding beyond six hours of life has been shown to decrease

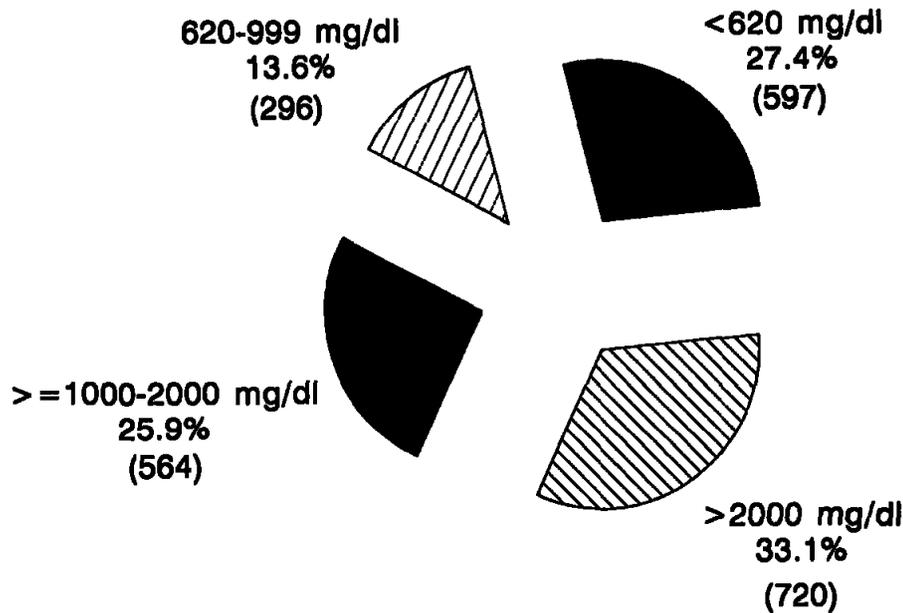
the efficiency of immunoglobulin absorption and increase the calf's susceptibility to disease.

The method of feeding colostrum to calves has also been investigated. These studies suggest that suckled colostrum provides better passive transfer to the calf. In many cases, however, this is impractical and it is frequently better to ensure colostrum ingestion than to wait until the calf consumes the colostrum by nipple feeder. While suckling the colostrum from the teat of the dam may theoretically provide the calf with the most efficient absorption, it can also delay the time of first feeding and reduce the total volume consumed. These factors likely account for the high rate of failure of passive transfer seen in many dairies that practice this approach to colostrum management. Feeding colostrum via nipple feeder is a good alternative, but for calves with weak suckle reflex it may require inordinate amounts of time. Although small family farms may have workers with the interest in ensuring colostrum intake by this method, time constraints may limit the success of nipple feeding in larger enterprises. Administration of colostrum by an esophageal feeder will introduce the colostrum into the rumen rather than the abomasum. When sufficient volume is provided, however, the majority will pass rapidly into the abomasum and ensure adequate absorption, even though the efficiency of absorption may be slightly impaired.

Management Of Colostrum Feeding

The issues discussed above suggest some practical guidelines for the management of colostrum supplementation to calves. Knowing that immunoglobulin absorption is critical to optimal calf health and knowing the factors that are most influential in passive Ig transfer provides some simple guidelines for colostrum feeding. Because most of the information presented above has been known for years, the most remarkable finding is the small number of dairies that monitor colostrum quality, manage colostrum feeding effectively and subsequently monitor passive transfer in their calves. Failure to adopt such colostrum management guidelines is reflected in the recent National Animal Health Monitoring System survey

National Dairy Heifer Evaluation Project Distribution of Immunoglobulin (IgG) Levels in Dairy Calves



Percent of Calves (# Sampled)

of dairy heifer calves, which showed that over 40% of the calves monitored on dairy farms across the country had serum Ig levels below 1,000 mg/dl. Over 27% of the calves tested had levels below 620 mg/dl, which was the lowest level measurable with the testing procedure used. If we assume greater than 2,000 mg/dl of circulating serum IgG is an acceptable level of passive Ig transfer, then 67% of the calves sampled had inadequate circulating levels. As testimony to the importance of this measurement, mortality rates in calves with less than 1,000 mg/dl were two-fold greater than in calves with higher levels of circulating IgG.

A reasonable understanding of the calf disease equation suggests that there is no absolute level of circulating IgG that will ensure calf health. Likewise, there is no single recommendation for colostrum management that will ensure appropriate passive

transfer in all calves. At a minimum, however, we can apply some simple guidelines. A list of suggested guidelines for colostrum management is provided at the end of this text. Given the information described briefly above, it is reasonable to provide calves with a minimum of 2 liters of colostrum within two hours of birth, followed by an additional 2 liters fed within 12 hours of birth. Such colostrum should at a minimum have an Ig concentration of 30 mg/ml, although 40-50 mg/ml would clearly be more desirable. Because older cows have more disease experience and provide more concentrated Ig levels in their first milking colostrum, the older animals should be selected as colostrum donors for newborn calves. The variation in Ig concentration of colostrum from even aged cows means that a screening of donors with a colostrometer can be effective in excluding low Ig producers from the donor group.

Freezing maintains the quality of colostrum for providing Ig transfer to newborn calves. Therefore, the highest quality colostrum can be identified and frozen for future use as the first feed for later newborn calves.

The calves at highest risk of contracting neonatal disease are those from first calf heifers. In general, heifers will have the highest rates of dystocia and this in turn will reduce the viability of their offspring. Dystocia has far reaching effects on the well being of a calf, but included among its effects are a reduced suckle reflex and increased time to first standing. Under unmanaged or natural suckling conditions, this reduced viability contributes to a very high rate of failure of passive transfer in affected calves. In addition, the dam has poorer colostrum on average than her older herdmates, compounding the effects of delayed time to suckling and reduced volume of colostrum consumption.

Although hand feeding via nipple may be the best artificial means of feeding the newborn calf, calves that fail to suckle within the first couple hours of life should be fed via esophageal intubation.

Monitoring the success of passive Ig transfer to newborn calves is a very important aspect of the colostrum management program. Measuring calves' blood protein concentration can be easily and economically accomplished and should be routinely performed on a percentage of calves less than seven days old. Adjustments in the colostrum program should be considered on the basis of these measurements. Equally important is a system to monitor calf health or disease problems. As discussed above, colostrum transfer is very important but by no means the only factor influencing calf disease. A monitoring system that provides information on both colostrum transfer and disease occurrence is invaluable in helping direct management changes to improve calf health. The herd veterinarian should be involved in diagnosis of specific disease problems. Some diseases, such as calf septicemia, can be very responsive to changes in colostrum management. While others, such as calf scours, are less responsive to colostrum, and their control requires close

attention to other management features. Findings from the National Animal Health Monitoring Systems survey highlight this important aspect of calf health problems. As mentioned above, mortality rates are greater in calves with poor colostrum transfer. Some calves will still get sick and die, however, even when Ig transfer has been highly successful. Data from this study suggests that approximately 30% of preweaned heifer-calf deaths could be prevented by ensuring all calves exceed 1,000 mg/dl of IgG at 24 to 48 hours. This also implies that approximately 70% of deaths would not be prevented through higher serum IgG.

Nonimmunoglobulin Components Of Colostrum

It has already been mentioned that colostrum contains additional benefits for the newborn calf beyond the provision of immunoglobulin. Other factors that enhance immunity are also secreted into the colostrum. These include immune-acting cells and a variety of nonimmunoglobulin proteins. The degree of benefit that they provide the calf is unknown, and there are no practical methods at this time for their evaluation on farm.

The more standard nutritional elements are also present in far greater abundance in colostrum than in normal cows' milk. The total solids in colostrum are approximately double those found in milk. Fat percentage is approximately 50% increased, while protein content is more than quadrupled. The bulk of the increased protein is, of course, immunoglobulin but casein content is also double that found in milk. Lactose is the only major constituent of colostrum that is lower (approximately 50%) than the level in normal milk. Thus, while the newborn calf's body reserves are not extravagant, the feeding of colostrum provides the calf with an abundance of protein and energy.

Associated with the high levels of fat in colostrum, the fat soluble vitamins A, D and E are also present at 4-8 times normal milk levels. Vitamin B12 is available at an 8-fold higher concentration. The macro-minerals (calcium, phosphorus and magnesium) are at double to quadruple normal milk levels, while the micronutrients (e.g. copper, iron, zinc, cobalt)

Guidelines For Colostral Management

• Management of colostrum supply:

Selection of donors.

1. Healthy dams with prolonged residence at the farm.
2. No precalving milking or milk loss.
3. Only first milking colostrum should be used for the first 14 hours of life.

Monitor colostrum quality with a colostrometer and exclude lower quality colostrum from the first feedings.

Maintain a frozen bank of high quality colostrum for use as needed.

• Management of colostrum feeding:

Feed a minimum of 5% of body weight (typically two quarts) at each colostrum feeding.

1. Feed first within two hours of birth and again within 12 hours of birth.
2. Several methods of feeding are acceptable.
3. After the first two feedings, continue to feed colostrum from later milking and of lower quality for its nutritional value.

• Monitoring the program:

On a routine, periodic basis (monthly), monitor calf health.

1. Incidence of specific diseases.
2. Age of disease onset.
3. Response to treatment.
4. Death rate.
5. Growth rate.

On a routine periodic basis (monthly), monitor blood of calves less than seven days old for Ig content.

are present at 5-20 times normal milk levels. Aside from its value as a source of immune enhancement, colostrum provides the calf with critically important nutrients.

Colostrum may be one of the most underutilized sources of dairy calf nutrition. Assuming that the average dairy cow produces between 40 and 50 kg of milk throughout the first six milkings, and that only 4-6 kg will be fed to the calf over the first 24 hours of life, there should be an abundance of extra colostrum available for calf feeding over the first one to two weeks of life. If a colostrum management pro-

gram is used whereby only first milking colostrum from mature cows is fed to newborn calves, then all heifer colostrum and aged cow colostrum from the second through sixth milkings could be made available as a source of nutrition. In many situations this may require the establishment of a colostrum storage pool. Numerous methods for pickling or fermenting colostrum have been successfully devised, allowing the use of colostrum as a nutritional source. Because of the higher solids content of colostrum, smaller amounts can be used or the colostrum can be mixed with water and similar calf performance

can be achieved as with milk replacer or discard mastitic milk. The composition of colostrum can be fairly similar to normal milk as early as the fourth postpartum milking and many dairymen will begin to market the milk by this time. It should be noted that most dry cow mastitis treatments recommend a discard time of six milkings post partum and attention to this factor may become more important as regulations on antibiotic residues in milk become more stringent with time. A good system for managing colostrum as a nutritional source for calves can be very important in the overall calf nutrition scheme.

Colostrum Supplements

There are presently several commercially available products marketed as colostrum supplements. These products are formulated either by spray drying dairy cow colostrum or by concentrating the whey proteins available from the manufacture of cheese. These products can be marketed as immunoglobulin supplements if they demonstrate efficacy in providing passive Ig transfer and protecting the colostrum-deprived calf against infectious challenge. Generally the products are guaranteed to contain a minimum level of bovine-origin immunoglobulin (e.g. 25 gm bovine Ig/package).

When mixed per label directions and fed to calves that are otherwise not provided a source of colostrum, these products will indeed improve the calf's chances of survival. On the other hand, the efficacy of these products to protect the calf against disease pales in comparison with natural first milking bovine colostrum. As mentioned earlier, the minimum total immunoglobulin mass recommended for administration to the newborn calf is 100 gm. To meet this level would require the feeding of three to four packages of the typical colostrum supplement

product. Furthermore, recent evidence suggests that the efficiency of absorption of immunoglobulin by the calf from such products is substantially less than the efficiency of absorption from natural colostrum. This means that even if equal quantities of immunoglobulin are fed, the calf receiving a colostrum supplement product will absorb only one-third to one-quarter as much immunoglobulin as it would from colostrum. With these considerations and additionally the cost of colostrum supplements, they are a very poor bargain. As the label suggests, these products are supplements, not substitutes. With the considerations described above, the dairyman will be much farther ahead to establish a good colostrum management program than to try to make up for management deficiencies by purchasing colostrum supplements.

Summary:

In the evaluation of dairy calf nutrition, one of the most important areas is the provision of colostrum to the newborn calf. Colostrum provides not only high quality and high density nutrition in the conventional sense of energy, protein, vitamins, and minerals, but is also the single most important factor in the enhancement of neonatal calf immune defenses. A variety of factors are involved in the establishment of good passive immunoglobulin transfer to calves and most of these factors can be positively influenced by a good colostrum management scheme. Despite increased knowledge about the importance of colostrum management in dairy calf health, recent surveys show inadequate passive transfer in 40-65% of dairy calves with a resultant negative impact on dairy calf health and survival. The institution of good colostrum management practices can have a substantial impact on overall calf performance.

Rational Treatment Of Clinical Mastitis

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Mastitis is the most common cause of antibiotic use in adult dairy cows. In surveys of well-managed herds with somatic cell counts (SCC) under 150,000/ml and virtually no mastitis due to coagulase-positive *Staphylococcus aureus* (Staph.) or *Streptococcus agalactiae* (Strep. ag.), 35-55% of lactations had one or more incidents of clinical mastitis^{2,4,7,8,9}. In such herds, 15-40% of the clinical cases had no bacteria isolated from the milk, 21-43% had coliforms, and 9-32% had environmental streptococci^{1,2,4,7}. This contrasts with high SCC herds with a significant prevalence of Staph. and Strep. ag., where most of the clinical mastitis is caused by those organisms⁴. As more herds respond to quality incentives and stricter SCC standards by controlling the contagious pathogens, we can expect the relative importance of the environmental pathogens to continue to increase.

The decision whether to treat clinical mastitis is an economic one, perhaps influenced by sentiment for a given cow. The future economic value of the cow in the milking herd, which depends upon her age, conformation, past performance and present reproductive status, must be considered. So must the costs and benefits of treatment, the value of discarded milk, the probability that treatment will fail, the likelihood of a relapse, the cow's present value as a cull, the availability of replacement animals, and the risk of errors causing antibiotic contamination of milk or the carcass. The likelihood of a treatment failure or a relapse is higher for a cow that has had previous unsuccessful mastitis treatments. Almost all studies of clinical mastitis treatment focus on bacteriological cure. There is very little economic information available to dairymen to help them make this daily decision.

Some dairymen and veterinarians have already decided that the risks of antibiotic use in most clinical mastitis cases exceed the benefits and have stopped treating clinical mastitis cows with antibiotics in herds with a low prevalence of the contagious organisms. They emphasize protocols of frequent milkout aided by oxytocin (OT) injections and anti-inflammatory drugs, along with heightened atten-

tion to management of housing, bedding and pre-milking hygiene to prevent infection with environmental pathogens. While the anecdotal reports about such programs are favorable, there is no published data about the rate of chronic or recurring infections in such herds compared to herds using antibiotics, nor on the effects of these infections on bulk tank SCC or subsequent milk yield.

Antibiotic Therapy Of Clinical Mastitis

To date there has been no published evidence that the economic benefits of antibiotic treatment of mild clinical mastitis outweigh the risks and costs. We have found only one published study on intramammary antibiotic treatment of mastitis under field conditions that includes untreated controls. In this abstract²⁵ results of three treatments were reported. Treatments occurred over an eight-year period. Treatment A was 100,000 IU penicillin and 150 mg novobiocin used twice. Treatment B was the same medication used three times. Treatment C was 200 mg of cephapirin used twice. Treatments A and B were used from 1979-85 and treatment C from 1985-87. Group D were untreated controls, which were split into two groups contemporaneous with the antibiotic-treated groups. No contagious pathogens were reported. The abstract does not state whether the treated quarters were clinically abnormal, and only bacterial cure rates are reported. For environmental staphylococci, cure rates were 62.9%, 70.4%, 67.3% and 0-7.3% for A, B, C and D, respectively. For environmental streptococci, cure rates were 50.21%, 58.3%, 48.7% and 1.9-7.7%. For all coliforms, cure rates were 23.2%, 13.0% and 7.9-13.4% for B, C and D. For *Klebsiella* sp., cure rates were 20.4%, 6.5% and 6.3-7.7% for B, C, and D. For *E. coli* alone, cure rates were 40.9%, 25.9% and 20-47.7% for B, C and D. Statistical tests of results were not reported, but group numbers ranged from 20-413. It would appear that these antibiotics were of benefit in the staphylococcal and streptococcal infections, and of marginal or no benefit in the coliform infections.

Intramammary infusion of pirlimycin, a lincosamide antibiotic, has been found to be effective as

against clinical mastitis caused by gram-positive organisms in research sponsored by its developer²⁶. These studies used both bacteriological cure and return of milk to normal as endpoints and included untreated controls. In an earlier study, 50 mg of pirlimycin (the dose in the commercially available intramammary product) was found to cure 66.7% (16/24) of cases of experimentally-induced Staph. mastitis. This cure rate was significantly different for that of untreated controls. Cure was defined as absence of Staph. bacteria at 11, 14, 21 and 28 days post-treatment. Cows had both subclinical and clinical mastitis in this trial.

Chamings³ reported an 87% clinical cure rate in cows that were not treated with antibiotics for mild clinical mastitis caused by Staph. and Streptococcus uberis. The bacteriological cure rate for both organisms was 19-20%. This study did not have a positive control group for comparison. This type of

mastitis is treated on most dairies with mastitis tubes, possibly in conjunction with extralabel parenteral antibiotics or anti-inflammatory drugs. All of the approved intramammary mastitis preparations on the market in the United States as of November, 1993, with the exception of pirlimycin, were tested against subclinical infections with gram-positive organisms. Only one has a label claim for mastitis caused by *E. coli*, which is the most frequently isolated udder pathogen in many outbreaks of clinical mastitis in herds with low SCC.

The pharmacology of mastitis therapy has recently been reviewed^{6,13,14}. Reasons why antibiotic therapy might fail are summarized in Table 1. Most treatment studies focus on bacteriological cures. Yet subclinical infections with environmental and contagious pathogens probably exist in every herd⁴. Clinical mastitis may be due to the flareup of subclinical infection in a stressed cow, and often signs

Table 1: Reasons For Failure Of Antibiotic Therapy Of Clinical Mastitis

A. Drug can not reach all sites of infection

1. Microabscess formation (Staph.)
2. Blockage of ducts with clots of denatured milk.
3. Poor distribution of drug in udder due to swelling, edema or intrinsic properties of drug.
4. Abscessation.
5. Fibrosis.
6. Intracellular bacteria (Staph.)

B. Bacteria already killed by cow's immune system before therapy begins.

C. Inadequate concentration of drug to effect killing.

1. Poor distribution of drug in udder.
2. Absorption of drug from milk into systemic circulation.
3. Failure of drug to be absorbed by affected tissues
4. Drug milked out at subsequent milking.
5. Failure of parenteral drug to cross blood-milk barrier
6. Failure of client or veterinarian to repeat treatments in time to maintain MIC in tissue long enough to effect killing.

D. Bacteria refractory to killing by drug.

1. Bacteria not in rapid growth phase required for drug to act.
2. Organism is resistant to usable antibiotics (e.g., Pseudomonas, Mycoplasma, yeasts, etc.)
3. Drug with gram-positive spectrum used on gram-negative infection.
4. Acquired resistance by organism.
5. Emergence of L-forms, 'naked' acapsular forms that resist beta-lactam antibiotics.

E. Reinfection of affected quarter.

of clinical mastitis persist after bacteria can no longer be isolated from the affected quarter. In the short run, the economically important clinical outcome in the treatment of clinical mastitis is not the absence of bacteria, but rather the return of milk and udder to their normal state so that the cow's milk can once again be sold.

All mastitis treatment studies have to define an endpoint, usually 10-28 days after diagnosis. Infections occurring in the same cow or quarter after this endpoint are assumed to be new infections. Absence of the original pathogen at the endpoint is assumed to be a cure. Few, if any, mastitis treatment studies focus on relapse or recurrence rate. Perusal of on-farm treatment records shows that on many farms many of the clinical cows are cows that have had bouts of clinical mastitis before. In the future, treatment studies should focus on relapse rates and should use DNA fingerprinting technology to distinguish between new and chronic infections.

Antibiotic Therapy Of Specific Mastitis Pathogens

Only one common pathogen, *Strep. ag.*, is highly sensitive to and easily cured by approved intramammary antibiotics used according to the label. In most herds with low SCC the prevalence of *Strep. ag.* is low or zero. Many such herds have no *Strep. ag.* isolated from bulk tank samples or clinical cows for years. In herds with *Strep. ag.* infected cows, use of intramammary antibiotics is easily justified on medical, if not economic grounds, because it stops the shedding of bacteria by the cow with clinical mastitis and because *Strep. ag.* is very sensitive to all of the antibiotic tubes on the market. Treatment of clinical mastitis in lactating cows is not effective, however, in reducing prevalence in the herd unless it is part of a total control program¹¹. Only an integrated program of teat dipping, milking machine maintenance,

milking hygiene and dry cow treatment can bring about a long-term reduction in prevalence.

While all mastitis tubes carry a label claim for *Staph.*, the cure rate is so low that dairymen are best advised to consider it negligible^{10,11,12}. The cure rate in *Staph.* cows is low because the organism forms

microabscesses in the udder tissue outside the ducts, where intramammary drugs can not reach it. It also can survive inside white blood cells, makes L-forms, and can acquire resistance to commonly used antibiotics¹⁰. The best hope for successful antibiotic treatment of *Staph.* infected cows is in young cows with recent infections. Parenteral treatment may increase the chance of a cure^{10, 28}. In herds with a high prevalence of *Staph.* infections,

the emphasis should be on teat dipping, culling, milking machine maintenance, milking hygiene and segregation of infected cows to gradually reduce the prevalence of the infection. Antibiotic treatment may reduce shedding of *Staph.* by clinical mastitis cows and thus help reduce the spread, but it will not reduce overall prevalence in the herd significantly¹¹.

In herds with low SCC and low prevalence of contagious pathogens, clinical experience and published surveys^{1,2,4,7} show that about 15-40% of pre-treatment milk samples from cows with clinical mastitis are negative for bacterial growth on blood agar. We presume that these samples containing too few organisms for a positive culture result reflect the ability of the cow's immune system to rid the affected quarter of pathogens. Antibiotic treatment of these cows is difficult to justify; the problem is that we can not know which cows they are until after treatment has to be initiated. The aim of treatment should be to return the quarter and the milk to normal, not to prevent the spread of infection. Anti-inflammatory drugs or immune modulators would seem indicated, rather than antibiotics.

Only an integrated program of teat dipping, milking machine maintenance, milking hygiene and dry cow treatment can bring about a long-term reduction in mastitis prevalence.

A fairly large group of so-called "minor" pathogens — minor in prevalence in the industry, not to the infected cow or her owner — are refractory to all antibiotic treatment. This group includes the genera *Mycoplasma*, *Pseudomonas*, *Pasteurella*, *Serratia*, *Prototheca*, *Mycobacterium*, *Nocardia*, *Bacillus*, the yeasts and fungi, and *Actinomyces pyogenes*.

In surveys of clinical mastitis in herds with low SCCs, coliform organisms account for about one-third of isolates from clinical cows. Coliform organisms can cause mastitis of severity ranging from subclinical to peracute. Erskine^{5,6} has shown that clinical signs appear in experimental coliform mastitis after bacterial numbers in milk have peaked, and that treatment of these cows with intramammary gentamicin did not affect clinical outcome. Toxic mastitis can be reproduced by infusing endotoxin without living organisms into the udder; most of the clinical signs of coliform mastitis are thought to be due to the effects of endotoxin⁵. Treatment should therefore aim primarily at removing endotoxin from the udder with frequent and complete milkout and at counteracting the effects of endotoxin with appropriate anti-inflammatory and supportive treatments, such as fluids and calcium²⁸. The most important part of a treatment protocol for coliform cows is to milk the quarter out completely and often, possibly with the help of OT injections. Unfortunately, treatment must begin before the organisms involved can be identified, and the appearance of the abnormal secretions alone is not a reliable basis for an etiologic diagnosis, except perhaps in the most severe cases. No studies have established the efficacy of antibiotic treatment of chronic or mild clinical coliform mastitis.

The environmental streptococci and the coliforms account for the majority of environmental clinical mastitis cases where a diagnosis is obtained. Philpot¹¹ cited a cure rate for clinical mas-

titis caused by environmental streptococci of 36%. Erskine⁶ states that acceptable cure rates (>75%) are attainable with a combination of intramammary antibiotics and intramuscular procaine penicillin G. Tyler¹³ states that response of clinical *Strep. uberis* infections to antibiotic therapy during lactation is poor, although a combination of parenteral and intramammary erythromycin appears to be the most efficacious treatment. Intramammary pirlimycin appears to be a promising treatment for clinical mastitis caused by environmental gram-positive organisms. More research is needed on these organisms, particularly on any long-range benefit from antibiotic treatment in eliminating chronic infections during lactation.

The challenges in treating clinical mastitis in a herd with low SCC are the impossibility of establishing an etiologic diagnosis at the time of first treatment, the fact that about a third of cows being treated have already cleared the infection, and the fact that in the case of the coliforms at least, the primary aim of treatment has to be to counteract the effects of endotoxin rather than reducing bacterial numbers. This must be accomplished without incurring undue risk of antibiotic contamination of milk, in the absence of clear experimental evidence from controlled trials that antibiotic treatment of mastitis is efficacious or cost-effective. Clearly more research is needed.

Table 2: Pretreatment bacterial isolates of 3 treatment groups in randomized field trials of therapies for mild clinical mastitis, California, 1991-92 (%)^{*}.

Variable	(Treatment)			P value
	Oxytocin	Amoxi-mast	Cefa-lak	
Coliform	33.3	41.9	37.3	0.93
Streptococcus sp.	26.7	23.0	26.7	
Other	15.2	10.8	13.3	
Negative	24.8	24.3	22.7	
Number of cows	105	74	75	

(^{*}: Of the 94 coliforms, 81 (86%) were *E.coli*. Of the 65 *Streptococcus sp.*, 27 (42%) were *S.uberis*, 19 (29%) were *S.dysgalactiae*, and 14 (22%) were *S.viridans*. Of the 34 'other' bacteria, 14 (41%) were *Staphylococcus sp.* (primarily *S.hyicus*), 9 (26%) were mixed infections, 3 (9%) were *Bacillus sp.* and 3 (9%) were *Corynebacterium sp.*)

California Study Of Efficacy Of Intramammary Antibiotics

A controlled study of intramammary treatment for mild clinical mastitis caused by environmental bacteria was recently completed at the Veterinary Medicine Teaching and Research Center of the University of California, Davis²⁴. We compared the efficacy of cephalosporin and amoxicillin mastitis tubes to that of OT alone in the treatment of mild clinical environmental mastitis in 254 quarters. Both tubes were used according to label instructions. Oxytocin cows received 100 units of OT intramuscularly just before milking. No other treatments were used on cows in the study. No contagious pathogens were isolated from any of the clinical cases. Cows treated in the study had mild mastitis, that is, abnormal milk with or without udder swelling, and no signs of systemic illness, and were randomly assigned to one of the three treatments. Cows that did not improve or got worse during the observation period were called treatment failures and withdrawn from the trial. A clinical cure was the return of the affected quarter and milk to normal at the eighth milking after initial diagnosis and treatment. A bacteriologic cure was the failure to isolate the primary pathogen present at the first milking at the eighth milking and at 20 days after initial treatment. Results are shown in tables 2, 3 and 4.

There were no significant differences in overall clinical cure rates by milking 9 after diagnosis or in bacterial cure rate by day 21 between antibiotic- and OT-treated quarters, although there was a significant effect of antibiotics on clinical cure in the category of 'other bacteria', which were pathogens other than coliforms and streptococci.

In this study tubes were used strictly according to label (two doses of cephalosporin and three of amoxicillin) and OT was given at three consecutive milkings. The protocol may not correspond with the way in which OT and antibiotic tubes are actually used on most dairy farms.

Further analysis of the data from two of the three herds involved in this trial by Van Eenennaam, et al.²⁹ shows there was no economic advantage to the oxytocin treatments, despite the lower cost of treatment, because of the higher relapse rate and greater number of additional mastitis infections incurred by the oxytocin group. There was no difference in the number of days of nonsalable milk over the lactations of the cows in the study between the oxytocin and the antibiotic treatments. Many of the relapses and reoccurrences in the oxytocin group occurred when the mastitic event was associated with an environmental *Streptococcus* species. It may be that in herds with a higher rate of CM infection caused by gram-negative organisms, the oxytocin-treated cows would not have experienced more reoccurrences and relapses. It should also be remembered that in this trial the antibiotics were used strictly according to the label. On commercial dairies,

Table 3: Bacterial and clinical cure (%) by treatment group and herd in randomized field trial of therapies for mild clinical mastitis, California, 1991-92.

Herd	Oxytocin	Treatment Amoxi-mast	Cefa-lak	P value
Bacterial cure %*				
Herd 1 (n=64)	10/26 (38.5)	9/20 (45.0)	11/18 (61.1)	0.33
Herd 2 (n=31)	6/10 (60.0)	6/10 (60.0)	6/11 (54.5)	0.96
Herd 3 (n=43)	12/21 (57.1)	3/11 (27.3)	5/11 (45.5)	0.27
Total (n=138)	28/57 (49.1)	18/41 (43.9)	22/40 (55.0)	0.61
Clinical cure %				
Herd 1 (n=82)	23/33 (69.7)	20/24 (83.3)	17/25 (68.0)	0.41
Herd 2 (n=86)	19/36 (52.8)	12/25 (48.0)	16/25 (64.0)	0.50
Herd 3 (n=86)	28/36 (77.8)	18/25 (72.0)	17/25 (68.0)	0.69
Total (n=254)	70/105 (66.7)	50/74 (67.6)	50/75 (66.7)	0.99

(*: Of 254 cases, 61 were culture negative prior to the 1st treatment, 43 were given additional treatment prior to 9th milking, 2 were treated between 9th milking and 21 days, 2 were dried prior to 21 days, 4 were culled before 9th milking, and 4 were culled before 21-day sample.)

where antibiotics may be used for more than two or three milkings, the economic impact of oxytocin and antibiotics might be different.

It would appear, then, that the primary reason to use oxytocin as a treatment for CM rather than antibiotics, at least in herds where environmental Streptococci are the predominant cause of CM, would be to allow earlier culling of treated cows and greater peace of mind to the dairyman regarding antibiotic residues in the bulk tank. While the short term outcomes are the same among antibiotic- and oxytocin-treated cows, there may be long-term benefits to using antibiotics in cows with gram-positive environmental mastitis.

Van Eenennaam, et al. also found that overall lactation milk production was not affected by CM, when monthly test day data was compared. These data may have masked short term milk losses that would have been obvious from daily milk yield records. Also, higher-yielding cows are more likely to develop CM, which may mask any milk yield loss caused by CM. However cows with CM were 2.1 times more likely to be culled than their herdmates.

Efficacy And Safety Of Oxytocin

I have been unable to find controlled research studies in the literature that document the effectiveness of OT therapy in clinical mastitis. One study¹⁵ showed that OT levels were higher in cows inoculated with 12.5 or 25 mcg of *E. coli* endotoxin in two quarters than in cows infused with saline. This suggests that lack of OT is not the reason for the often observed failure of milk letdown in cows with clinical coliform mastitis.

The optimal dosage of OT and the optimal time of administration has not been established by research. Some clinicians have expressed the opinion that a small dose should be given at the end of milking to aid in the expulsion of residual milk and to reduce strippings. The label dose for aid in milk letdown is 10-20 IU, while that for obstetrical use is 100 IU. One researcher recently confirmed that 20 IU would elicit milk letdown in 1.5-2 minutes and would also aid in ejection of strippings milk¹⁶.

Oxytocin is rapidly inactivated in the body and the potential for toxicity is low. Occasional anaphylactic reactions are reported in women given OT at

parturition. No ill effects on health were found in a study in which cows received twice daily doses of 20 IU OT at milking throughout lactation¹⁶. Reproductive performance was the same in the treated and control groups in this study.

Oxytocin is part of the normal control mechanism of luteolysis in the estrous cycle in cattle. Oxytocin is secreted by the corpus luteum and acts on uterine receptors in the estrogen-primed uterus

Table 4: Bacterial and clinical cure (%) by treatment group and bacterium isolated at pretreatment sampling in randomized field trial of therapies for mild clinical mastitis, California, 1991-92.

Herd	Treatment			P value
	Oxytocin	Amoxi-mast	Cefa-lak	
Bacterial cure %*				
Coliforms (n=63)	10/26 (38.5)	9/20 (45.0)	11/18 (61.1)	0.33
Streptococcus sp. (n=49)	6/10 (60.0)	6/10 (60.0)	6/11 (54.5)	0.96
Other bacteria (n=26)	12/21 (57.1)	3/11 (27.3)	5/11 (45.5)	0.27
Positive cultures (n=138)	28/57 (49.1)	18/41 (43.9)	22/40 (55.0)	0.61
Clinical cure %				
Coliforms (n=94)	23/33 (69.7)	20/24 (83.3)	17/25 (68.0)	0.41
Streptococcus sp. (n=65)	19/36 (52.8)	12/25 (48.0)	16/25 (64.0)	0.50
Other bacteria (n=34)	28/36 (77.8)	18/25 (72.0)	17/25 (68.0)	0.69
No bacteria isolated (n=61)	24/26 (92.3)	13/18 (72.2)	13/17 (76.5)	0.18
Total cultures (n=254)	70/105 (66.7)	50/74 (67.6)	50/75 (66.7)	0.99

(*: Of 254 cases, 61 were culture negative prior to the 1st treatment, 43 were given additional treatment prior to 9th milking, 2 were treated between 9th milking and 21 days, 2 were dried prior to 21 days, 4 were culled before 9th milking, and 4 were culled before 21-day sample. There were no contagious pathogens cultured.)

during late diestrus¹⁷. The binding of OT to the uterine receptors in turn triggers the pulsatile secretion of prostaglandin F₂ (PGF) by the uterus. This positive feedback mechanism causes luteolysis and allows estrus to occur. Injection of 230 IU of OT in cows on days 2-6 of the estrous cycle caused a significant increase in PGF concentration in the blood and shortened the cycle of two of six treated cows to 10-12 days¹⁸. However in another study injection of about 230 IU (.33 IU/kg) at days 5, 10 and 15 of the cycle had no effect on cycle length, estradiol, or progesterone concentrations¹⁹. On the other hand, continuous infusion of OT in open heifers caused lengthened estrus cycles¹⁷. The PGF response to OT injection is suppressed after day 6 of the cycle and restored at day 13-16²⁰. Immunization of sheep against OT prolongs the luteal phase of the estrous cycle²¹. OT also has a direct inhibitory effect on gonadotrophin-stimulated steroid hormone (progesterone, in particular) in isolated luteal cells²¹. Exogenous OT does not induce parturition in late-gestation cattle.

Oxytocin also has a role in the effects of heat stress on reproduction. Chronically heat-stressed ewes have smaller lambs than unstressed ewes, partly in response to reduced uterine blood flow²². The decrease in uterine blood flow is accompanied by a 60% increase in serum OT. Uterine blood flow was also reduced by exogenous OT and antidiuretic hormone (ADH) injections. OT and ADH are similar in structure and are both secreted by the posterior pituitary. Heat-stressed pregnant heifers tended to have a higher PGF response to the injection of 100 IU OT. Five of six heat stressed pregnant heifers, compared to 1/5 nonstressed heifers, were classified as responders to OT (PGF concentration >193 pg/ml)²³. It would appear from this study that heat stress antagonizes the suppressive effect of the embryo on uterine secretion of PGF in response to OT.

In summary, OT used at the low doses used for milk ejection has little toxic potential aside from rare anaphylactic reactions. However, at higher doses it has been reported to affect cyclicity of cows in the early and late parts of the cycle and the level of prog-

esterone secreted by the corpus luteum. Heat-stressed animals may be slightly more likely to abort due to OT-induced PGF release from the uterus, and chronic OT administration may reduce uterine blood flow and fetal size and viability. One study reported no health or reproductive effects from twice-daily injections of 20 IU of OT¹⁶. Since endotoxin can cause prostaglandin release and luteolysis, it would be hard to determine whether altered cyclicity or abortion was due to mastitis itself or to OT used as an aid in mastitis therapy.

Protocols For Mastitis Treatment On Dairy Farms

In the past, the standard recommendation was to treat all cows with clinical mastitis with antibiotic tubes used according to the label. In herds with low SCC where all clinical mastitis is caused by environmental bacteria, we can design better treatment protocols that minimize antibiotic use, reduce the risk of residues, and still allow flexibility to beef affected cows if treatment does not work. A responsible treatment protocol requires that permanent records of clinical mastitis be kept so that a cow's past history can be consulted before treatment is initiated. Since almost any rational treatment protocol for clinical mastitis will include off-label treatments, the co-operation of a veterinarian is essential for its design and implementation.

Clinical mastitis should be classified before treatment as mild or severe. Mild mastitis would be characterized by abnormal milk and slight udder swelling, while severe mastitis would include abnormal milk, severe swelling, the risk of losing the quarter, and systemic illness (fever, off feed, diarrhea).

Before a protocol is put in place, the veterinarian should collect and analyze the results of sampling of clinical mastitis cows to determine the pathogens generally involved on the particular farm in different seasons. On a farm where clinical mastitis is caused by *Strep. ag.*, for example, antibiotic tubes should be used on all clinical cases. On a farm where a third of the clinical samples show no growth and half yield *E. coli*, antibiotic use may be justified for very few cows. In a herd with a high incidence of envi-

ronmental gram-positive infections, some combination of intramammary and systemic antibiotics may be effective. Dairy personnel should be trained to look at the cow's record before beginning a course of lactating cow treatment. The people making the treatment decisions, usually milkers or herdsmen, need to be trained and trusted to make these decisions properly. The veterinarian and the owner should develop

a treatment protocol based on the known past history of pathogens in the herd, age of the cow, reproductive status, milk yield, relative value in the herd, past mastitis history, other unsoundnesses (locomotor problems, poor udder conformation, etc.), and the severity of clinical signs. For example, a cow that is below the herd average, open, and late in lactation will most likely be culled eventually anyway and might as well be culled now that she has mastitis. An average first-lactation cow that is late in gestation should be dried off early, since dry cow preparations are stronger, stay in the udder longer, are more likely to clear up the infection than lactating cow tubes, and present less risk of contaminating the bulk tank with antibiotics. Cows with persistent or recurring infections despite past treatment are unlikely to respond to a repetition of the same treatment protocol. The risky approach on these cows is to turn to extralabel use of parenteral antibiotics, with all of the risk of illegal residues it entails. A safer approach is to evaluate the cow's record and the severity of the infection and decide either to cull the cow, dry her off, treat her, or to let her recover on her own. A young, high-yielding cow in early lactation with mild mastitis might be treated aggressively, with an emphasis on frequent and complete milkout.

Treatment protocols should be modified to fit the culling philosophy and goals of each producer. A producer who is trying to build up herd numbers, for example, may be more inclined to dry off a pregnant cow with clinical mastitis than one whose facil-

Since almost any rational treatment protocol for clinical mastitis will include off-label treatments, the cooperation of a veterinarian is essential for its design and implementation.

ity is overcrowded and is looking for room for a new heifer.

On large dairies an aid in the management of clinical mastitis is to have a designated mastitis string, which is milked last, just before the hospital or antibiotic string. The mastitis string is milked into the bulk tank. It contains all cows that have had clinical mastitis during the current lactation, chronic high SCC cows, and cows known to be

infected with *Staph.* that the owner does not want to cull. On some dairies it might include slow-milking cows and cows with poor udder shape that require extra attention at milking time. On others the slow cows are in a separate group. Cows in the mastitis string are generally not to be treated with antibiotics when they get clinical mastitis again. They are either culled or milked out with the aid of OT injections until their milk is normal. Since abnormal milk may not be put into the bulk tank, cows in this group with clinical mastitis must either be milked into a separate bucket or put in the hospital string until their milk is normal. Cows may leave the mastitis pen only to be dried-off or culled, or if their individual SCC remains below 200,000 for three consecutive test days and they are not known to be infected with a contagious pathogen.

On dairy farms where facilities permit, one small pen may be designated a non-antibiotic hospital. This pen can then be milked at twice the frequency of the other pens by bringing the cows to be milked in the middle of each shift. Since no antibiotics are used in this pen, the pipeline does not have to be washed after it is milked, and the milk can be diverted to calf milk or put down the drain.

Here is a suggested treatment protocol for dairy farms with no clinical mastitis caused by contagious organisms. It is assumed that the cow in question is considered to be worth treating. Cows that have had more than three or four bouts of clinical mastitis in a lactation should be considered for the chronic pen,

culling or drying off. Very mild cases, where a few flakes of garget in the first squirts of milk give way to normal milk, would be recorded but milked into the bulk tank. In mild cases where milk remained abnormal but the cow was not off feed or depressed, the cow would be milked more frequently than normal with the aid of OT injections. A sample would be taken at initial diagnosis, frozen, and discarded if the cow responded to the frequent milkout treatment. If the quarter did not improve rapidly, the sample would be taken to the laboratory. If the bacteria isolated are susceptible to treatment, antibiotic treatment would be initiated. If not, the cow would continue on frequent milkout, or the quarter would be dried off, or the cow sold. In cases of severe, acute mastitis in which the cow become depressed and goes off feed, treatment would emphasize frequent milkout, use of anti-inflammatory drugs, and supportive care. With this treatment protocol antibiotic use is limited to the comparatively small group of mastitis cows that will benefit from it, and residue risk is greatly reduced.

Treatment of clinical mastitis is the most common use of antibiotics on dairy farms and the most common cause of illegal antibiotic residues. On well-managed dairy farms most mastitis is caused by the environmental pathogens. There is no data from well-controlled studies demonstrating the efficacy of antibiotic treatment of clinical mastitis caused by the environmental pathogens, nor on any benefit of antibiotic treatment on chronic or persistent infections. However, even in the absence of data the veterinarian can be very helpful in developing treatment protocols that greatly reduce the use of antibiotics and decrease the risk of violative residues.

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notes

Neosporosis: A Newly Recognized Cause Of Abortion In Dairy Cattle

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Neospora is a newly recognized genus that was first identified as a *Toxoplasma*-like protozoa in dogs with encephalomyelitis and myositis¹⁵ and later shown to be the same *Neospora caninum* parasite that was isolated from a litter of puppies in the United States^{14,24,27,29}.

The genus designation *Neospora* has since been applied to a similar protozoal parasite identified in livestock^{9,51}. In 1991, the first bovine *Neospora* isolates were obtained from aborted fetuses and these isolates have been maintained in continuous cell culture¹⁸. Whether the canine isolate (*Neospora caninum*) and bovine isolate represent identical or different species is not known. At present, the infection in livestock is most appropriately referred to as a *Neospora* species.

Neospora have morphologic similarities to *Toxoplasma gondii*, but can be antigenically differentiated by immunohistochemistry.¹² By light microscopy, *Neospora* can only be differentiated from *Toxoplasma* in the tissue cyst stage where *Neospora* often has a thicker cyst wall. In addition, there are distinct ultrastructural differences between *Toxoplasma gondii* and *Neospora*.^{12,39}

Infection due to *Neospora* has been reported in various species of livestock, including cattle^{1,5,8,9,11,12,20,25,28,30,33,35,38,41,43,46,49,50,51,52,56} sheep^{26,31} goats^{11,23} horses³⁴ and deer⁵⁵. Although only recently recognized, bovine neosporosis has emerged as an important reproductive disease. Since its first association with an abortion storm in 1987 in a dairy in New Mexico⁵¹ there have been reports of *Neospora* abortions in California and the Midwest which have confirmed this infection as a significant cause of abortion, particularly among dairy cattle^{1,5,9,41,49}. Retrospective studies in California suggest that the parasite has been endemic since at least 1985⁶.

In California, 18-19% of all aborted bovine fetuses submitted to the California Veterinary Diagnostic Laboratory System (CVDLS) are diagnosed with this infection^{5,9}. In dairy cattle submissions from California, the proportion of *Neospora* abortion is even higher, 24.4%⁶. In a Midwest survey, *Neospora* infection was identified in 2.7% of all cattle abor-

tions and was the largest cause of abortion in dairy cattle submissions.⁴¹

Bovine neosporosis has a worldwide distribution and has been diagnosed in the United States,³⁸ Canada,^{*}³⁸ Mexico,¹ Britain,^{20,44,46} Netherlands,⁵⁶ Denmark,² Australia,^{25,42} New Zealand,⁵² South Africa,³⁵ and Japan^{*,43}. Within the United States 28 states have reported cases including Alabama,³⁸ Arizona,^{*,41} California,^{3-6,8-12} Colorado,^{*,49} Georgia,³⁸ Idaho,^{*} Illinois,^{*} Indiana,²⁸ Iowa,⁴¹ Kansas,^{*} Maryland,^{*,33} Michigan,^{*} Minnesota,^{*,41} Missouri,^{*} Montana,^{*} Nebraska,³⁸ New Mexico,⁵¹ New York,^{*} North Dakota,^{*} Ohio,^{*} Oklahoma,^{*} Texas,^{*,41} South Dakota,⁴¹ Utah,^{*} Virginia,^{*} Washington,^{48,50} West Virginia^{*} and Wisconsin^{*,41}.

Pathogenesis:

The pathogenic potential of bovine *Neospora* sp. has been confirmed by experimental infection of pregnant cattle resulting in fetal death and in the birth of an in utero exposed or congenitally infected calf³. *Neospora caninum* from dogs also has been experimentally inoculated into pregnant cattle and sheep, resulting in transplacental fetal infection in a cow and abortion in sheep^{31,32}.

The natural route of infection and life cycle of *Neospora* is unknown, but similarities to other apicomplexan coccidia, particularly *Toxoplasma*, suggests that postnatal infection probably is acquired through oral ingestion of coccidial oocysts shed from an unidentified carnivorous definitive host. Attempts are being made to identify the definitive host of bovine *Neospora*. To date, dogs, cats, rats and mice have been screened for *Neospora* coccidia following experimental infection with bovine *Neospora* sp. (Conrad P and Barr B, unpublished data, 1992) and dogs, cats, and raccoons have been screened for *N. caninum* coccidia following experimental infections with *N. caninum*³⁸, but no fecal oocysts identified as *Neospora* have been identified in these species. Tachyzoites and tissue cysts are the two morphologic forms currently identified.

Clinical Presentation:

Although congenital *Neospora* infections have been diagnosed in most of the domestic livestock

species, cattle are the only livestock species in which there is sufficient information available concerning the natural infection to describe its clinical features. There are no signs of clinical illness in cows that abort due to *Neospora* infection. The aborted fetuses are usually autolyzed, with no gross lesions, and placentas are not retained. Abortions

have been diagnosed in both heifers and cows from 3 months gestation to term^{5,9,33}. Whether *Neospora* infection can cause reproductive problems in the first trimester of gestation is unknown. A majority (78%) of *Neospora* abortions occur between 4-6 months gestation and this pattern of mid-gestation abortion is distinctive from other diagnosed causes of infectious abortion in dairy cattle which tend to occur later in gestation⁶.

While *Neospora* infections occur in both dairy and beef cattle, most reports attributing significant numbers of abortions to this infection have been associated with dairy cattle, particularly those in drylot dairies^{1,3-6,8,9,41,49,51}. This apparent disparity between beef and dairy cattle is not thought to represent breed susceptibility, since beef cattle have been shown to be susceptible to experimental infection¹³ and both congenital infections and abortions due to *Neospora* have been documented in beef breeds^{*,28,30,33,48}.

It is probable that the environment of the drylot dairy is more conducive to the spread and transmission of this disease. Cattle in drylot dairies are densely populated and fed a variety of harvested feeds and commodities which are frequently stored on or around the dairy prior to being mixed and fed. These feeding practices offer many opportunities for fecal contamination, either on the dairy or in the crop in the field, of any of these individual ration components which would then be mixed and fed, efficiently exposing much of the herd. This pattern of increased exposure and disease associated with

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intensive management mimics factors affecting the incidence of *Toxoplasma* abortion in sheep flocks.

Neospora infection has been identified throughout California in over a third of the dairy herds submitting aborted fetuses to the CVDLS^{6,9}. The herd incidence of abortion due to this infection can be quite variable.

Rare sporadic cases may occur in some dairies with a nominal abortion rate. However, explosive outbreaks of *Neospora* abortion may occur.

A well documented example involved a group of 147 drylot dairy heifers in which 27 (18%) aborted during a six-week period and all fetuses examined (17) were diagnosed with *Neospora* infection (Reynolds J, personal communication, Nov. 1993). In some instances, up to 5% of pregnant cattle have aborted due to neosporosis within one to three months. Annual herd abortion rates up to 30% have been reported in dairies with *Neospora* abortions and these abortions may continue to occur over a period of several years^{*,1,49}. Over a one-year period of time, all aborted fetuses available on 26 selected California dairies were collected and submitted to the CVDLS for diagnosis. A total of 266 abortions were submitted, of which 113 (42.5%) were confirmed *Neospora* abortions from 19 dairies (73%)⁷. In addition to abortion, fetal mummification has been associated with *Neospora* outbreaks^{*,49}. *Neospora* abortions occur throughout the year but there is possibly a small increased risk of abortion during the late fall and winter⁵³.

Bovine fetal *Neospora* infection does not always produce fetal death resulting in abortion or stillbirth. Fetal infection may result in the birth of live full-term congenitally affected calves^{11,12,20,25,28,30,33,44,48}. Central nervous system infection and damage in these calves results in highly variable clinical signs which are often limited to limb dysfunctions, ranging from mild proprioceptive defects to complete paralysis.

Microscopically, there is a multifocal protozoal encephalomyelitis which may be particularly localized in the spinal cord gray matter. However, calves may have serologic and histopathologic evidence of in utero *Neospora* exposure or congenital infection with no obvious signs of clinical postnatal disease. A consistent finding in these calves is a high precolostral antibody titer to *Neospora* which are useful in detecting in utero exposed or congenitally infected calves¹¹. In a survey of calves on a dairy with a previous history of *Neospora* abortions, 67/189 newborn calves (35%) had serologic evidence of in utero *Neospora* infection, with no evidence of increased morbidity or mortality in these calves⁴⁷. The apparent wide variability in clinical presentation of these in utero exposed or congenitally infected calves may be due to multiple factors, including the age and immune development of the fetus at the time of exposure to *Neospora*, as well as the distribution of the lesions in the central nervous system.

Evidence is accumulating that cows that abort a *Neospora*-infected fetus may have additional infected fetuses in subsequent pregnancies. Barr and colleagues identified 5 calves born to 4 cows with *Neospora* abortions in the previous pregnancy. In all calves there was serologic and histopathologic evidence of congenital infection¹¹.

Repeat abortions can also occur. In a survey of abortions in drylot dairies in California, two confirmed *Neospora* abortions were identified in 4 of 41 cows in which information concerning other pregnancies was available⁷. It is not known whether these repeat transplacental infections are the result of a release of parasites from tissue cysts in the dam or from reinfection of the dam from the environment. However, there is recent evidence that suggests that chronic persistent infections do occur. In a survey of heifer calves in a known *Neospora* dairy herd, 25 calves with serologic evidence of congenital

exposure were compared with 25 serologically negative cohorts. The two groups were similar until pregnancy and calving. At the present time 20 of the 50 heifers have calved. All calves born to heifers with an history of congenital *Neospora* exposure have had elevated *Neospora* titers (8 of 8) and all negative heifers have had serologically negative calves (12 of 12) (Mark Anderson and Jim Reynolds, unpublished data, 1995).

The results suggest both that a chronic latent infection can occur with *Neospora* and, most interestingly, that there is vertical transmission of this disease through generations of cattle with little obvious clinical symptoms.

Diagnosis:

The confirmation of a suspect *Neospora* infection will require the assistance of a veterinary diagnostic laboratory. The preferred samples in cases of abortion include one or more aborted fetuses submitted with placenta and sera from the dam. The aborted fetus is usually autolyzed with serosanguinous fluid accumulation in body cavities. Rarely there are subtle gross lesions, consisting of pale white foci in the skeletal muscles or the heart. Histologic lesions consist of widespread nonsuppurative infiltrates. The most diagnostically significant lesions are found in the brain and consist of scattered foci of nonsuppurative cellular infiltrates with occasional foci of necrosis. Protozoa are not usually seen on routinely stained slides. Other histologic lesions that are consistently found include nonsuppurative epicarditis and/or myocarditis, focal nonsuppurative myositis and nonsuppurative portal hepatitis, frequently with focal hepatic necrosis.⁹ The presumptive diagnosis of protozoal infection can usually be made on the basis of histologic lesions. Immunohistochemistry using antibodies to *Neospora caninum*³⁷ or the bovine *Neospora* isolate^{12,13} is an effective method to identify *Neospora* in fetal tissues and establish a definitive diagnosis.

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Recently, a monoclonal antibody against *Neospora caninum* has been developed which can also be used to detect infection in aborted fetuses¹⁷. *Neospora* immunohistochemistry is most successful on sections of fetal brain, although the parasites are also frequently present in the lung, kidney and skeletal muscle (Anderson M., unpublished data, 1994). Immunohistochemistry has been successfully employed to diagnose *Neospora* infections in mummified fetuses although the autolytic state of these fetuses diminishes the diagnostic accuracy (Anderson M, Barr B, unpublished data, 1994).

Diagnosis of congenital *Neospora* infection in calves on the basis of necropsy and histopathology may be difficult due to the variability of histologic lesions and numbers of parasites present¹². The most characteristic lesions are in the spinal cord, consisting of a multifocal nonsuppurative myelitis. In some cases thick-walled tissue cysts may be present within neurons. However, these tissue cysts may be extremely rare in many in utero exposed calves, making it difficult to establish a diagnosis on the basis of *Neospora* immunohistochemistry alone.

Neospora serology, utilizing an indirect fluorescent antibody (IFA) test, has proven effective in detecting elevated *Neospora* antibodies in the serum of congenitally infected or in utero exposed calves^{12,19}. In addition, the *Neospora* IFA test may also be useful in establishing the diagnosis in aborted fetuses, since most infected fetuses older than 5 months gestation have elevated *Neospora* antibody titers. However, just as with *Toxoplasma* infections, a negative fetal *Neospora* IFA titer does not rule out the possibility of infection.

While serology is an effective diagnostic tool in identifying *Neospora* infection in aborted fetuses and in utero exposed calves, the use of *Neospora* IFA for serodiagnosis in the adult cow may be less reliable. A significant portion (22%) of cows aborting a *Neospora* infected fetus had *Neospora* IFA titers that were within 2 dilutions of titers in presumed noninfected cattle¹⁹. In addition, within 2-5 months following abortion, the previously elevated titers in cows aborting a *Neospora* infected fetus

may drop to levels similar to noninfected cattle¹⁹. Laboratories utilizing this test must establish appropriate cut-off titers using standardized sera and should attempt to confirm their positive results by the identification of parasites in aborted fetuses.

Control And Prevention:

At present, there are no proven methods available for the control, prevention or treatment of bovine neosporosis as there is insufficient information on the biology of this parasite, including the mode of transmission, on which to base specific recommendations. However, it is prudent to remove all potentially infected tissues, such as aborted fetuses and placentas from the environment, that might serve as a source of infection for susceptible hosts. In addition, fecal contamination of feed and water sources by other animals should be minimized. It is apparent that fecal contamination of the environment or feeds of cattle is extremely common since virtually all cattle are infected with *Sarcocystis cruzi* through ingestion of coccidia from a canidae definitive host. As is the case with toxoplasmosis, development of an effective *Neospora* vaccine will be extremely difficult. At present, no culling recommendations can be offered for cows that have a *Neospora* abortion. Although repeat abortions or repeat congenital infections might occur in these animals, there is insufficient information available to estimate their future reproductive performance.

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notes

"The milking system is the most important equipment a dairy farmer owns. It "harvests" the cash crop – milk. It comes into intimate contact with every cow two or more times a day. It's used 365 days of the year – no matter what the weather, and even when the calendar says it's a holiday".

That's the introduction for a new booklet, "Maximizing the Milk Harvest" published by the Milking Machine Manufacturers Council (MMMC, 1993). This excellent booklet is a revised edition of the long-running series published by the MMMC. It has been revised completely because, in the last five years, remarkable changes have occurred in our knowledge and understanding of the milking and cleaning performance of milking systems.

Recent field studies suggest that large milking systems tend to be over-dimensioned and under-designed. New system evaluation procedures indicate that the performance and energy efficiency of many large milking systems could be improved markedly by a few simple design changes, and by more thorough equipment service and maintenance programs.

Machine milking is a unique example of a mechanical process that requires the willing cooperation of an animal for its success. Therefore, let's start with a brief review of the changing physiological characteristics and needs of high-producing dairy cows.

The principles for good milking are well known: cows' teats should be clean and dry for milking; cows should be milked gently, quickly and completely, with minimal machine stripping or over-milking. However, the ways in which these principles are applied is changing as milk production levels continue to rise, because high producing cows have:

- 1). Lower pre-milking stimulus requirements than low producers.
- 2). Longer milking times (in spite of their higher average milk flow rates).

- 3). Higher incidence of teat-end rings, or eversion.

- 4). Higher risk of new mastitis infections.

Here's a brief summary of the evidence for, and implications of, these changes.

Response to Premilking Manual Stimulation: Present-day, high-producing Holstein-Friesian cows appear to need little or no manual stimulation to maximize milk production. Although no data have been published for cows producing 20,000 lbs. milk or more per year, all of the available evidence from studies with lower producing cows indicates that high producers are relatively easy to stimulate and that oxytocin half-life is unlikely to be a limiting factor (see review by Mein and Thompson, 1993). Therefore, the basis of good premilking udder preparation should be to ensure that teat cups are applied:

- To visibly clean, dry teats with meticulous attention to detail, to reduce the risk of mastitis and to maintain top quality milk.

- At or soon after the time of milk ejection, when teats become plump with milk.

- With minimal time and effort for manual stimulation.

Longer Milking Times: Although peak flow rates and average milking rates tend to be higher in higher producing herds, it is quite clear that high-producing cows take longer to milk out. Field studies in England, France and the U.S. (Stewart et al, 1993), and the simulation studies of Thomas et al (1993) all show remarkably consistent results. On average, cows giving 20-25 lbs. of milk per milking take about 5 minutes to milk, and cows producing 30-35 lbs. take about 6 minutes. The conclusion: add 1 minute to the mean milking time per cow for each 10 lbs. increase in mean milk yield per milking.

The combined effects of longer milk-out times and shorter pre-milking prepping times in high-producing herds means that for optimum or more efficient labor utilization milking systems should be designed with more units per operator. Simulation studies on parlor performance by Thomas et al (1994) indicate that a 10-lb. increase in mean milk yield per cow per milking would reduce the num-

ber of parlor turns by about 0.7 turns per hour in double-16 or double-20 parlors.

Can we adjust the milking machine so that cows producing 40 lbs. per milking could still be milked out in 6 minutes? The three easiest variables with the greatest influence are vacuum level, pulsation ratio, and the threshold settings on automatic cluster detachers.

It is common knowledge that increasing the system vacuum level, eg. from 13.5 to 15 inches of mercury ("Hg) and widening the pulsator ratio (eg. from 50:50 to 60:40 or to 70:30) results in faster milking times. On the other hand, a comprehensive review of teat tissue reactions to milking indicates that machine-induced teat congestion and edema, incidence of teat lesions and, perhaps, new mastitis infection rates, tend to increase with increasing vacuum level and wider pulsator ratio (*IDF, 1994*).

It seems that we must reach a compromise between machine settings for fast milking and for maintaining healthy teats.

Typically, the system vacuum should be set between 12.5" and 13.5" Hg for lowline milking, and between 14" and 15" Hg for highline milking, according to guidelines in the *MMMC* booklet (1993). Usually, this will result in a mean vacuum level in the claw within the range 10.5" and 12.5" Hg during peak milk flow for a representative sample of cows. I try to set the system vacuum at the higher end of these ranges so that cows are milked as fast as possible, but still within the range recommended to maintain gentle milking conditions.

Pulsator ratios of 60:40 to 70:30 milk cows quickly and comfortably when narrow-bore teat cup liners are used. Because there's less margin for error at wide ratios like 70:30, excellent testing and ser-

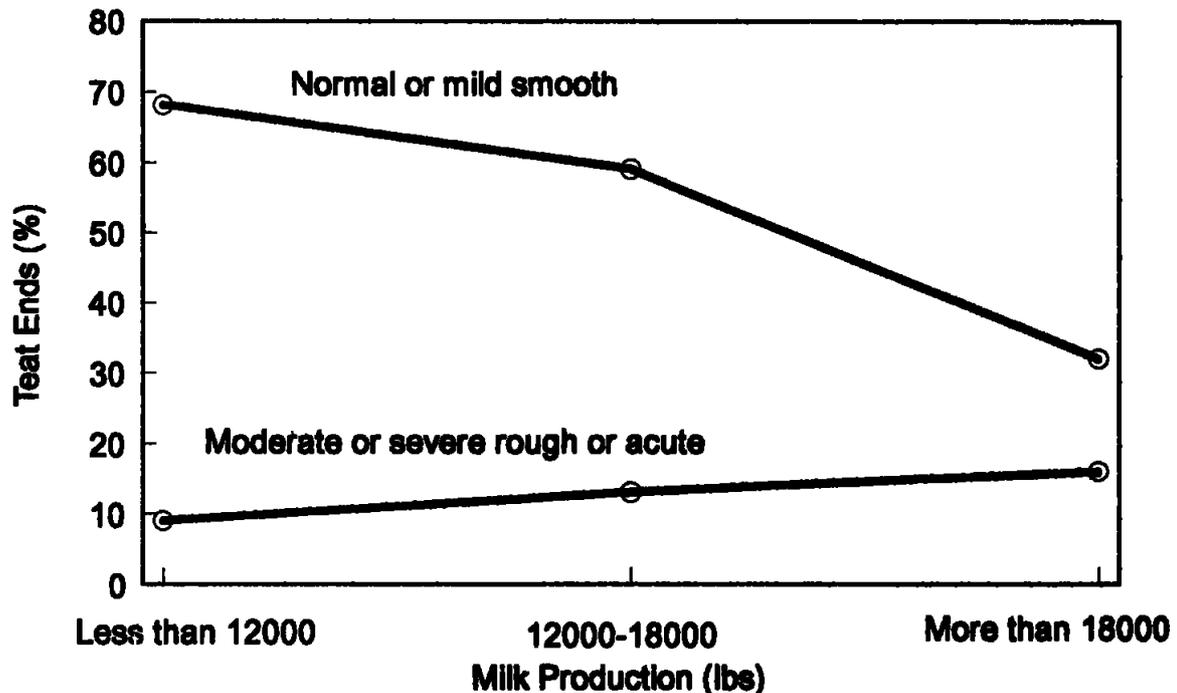


Figure 1. Changes in teat end condition with 305-d milk production. [Adapted from Selber, 1979]

vice programs are needed to maintain pulsators in top condition.

Pulsation rates somewhere around 50-60 cycles per minute work fine. The small additional gain in milking speed at higher pulsation rates tends to be offset by poorer teat-end condition. Although the system vacuum level could be lowered to compensate for this more aggressive pulsation action, milking speed would then be slower!

Average milking time per cow was reduced by 0.5 minutes, and teat condition was improved, in a Danish experiment when the threshold setting on the automatic take-offs was raised from 0.44 to 0.9 lbs. milk per minute (Rasmussen, 1992). Milk yield and milk composition were the same for each group of cows. Alternatively, the delay time could be reduced from about 20-30 seconds after the threshold flow rate setting down to 10 seconds. This change would save about 20-40 seconds per parlor turn.

Teat End Condition: Healthy teat skin provides the best defense against all types of pathogens. Furthermore, smooth healthy teat skin is easier to clean and easier to keep clean compared with rough or damaged teat surfaces. The act of milking aggravates all types of teat lesions, however. Machine milking is the main cause of teat canal erosion (variously known as teat orifice "eversion", "rings", fibrous rings or epithelial hyperplasia), hemorrhagic blisters near the teat end, and much teat chapping.

A high prevalence of teat end lesions is common in high-producing cows milked by machine, especially in early lactation. The progressive deterioration in teat end condition with increasing 305-day milk yield is shown in Figure 1 on the preceding page. Less than 9% of teat ends were classed as normal for cows giving more than 18,000 lbs. milk (305d) (Seiber, 1979). The design and action of the teat cup might need to be modified to maintain the teats of high-producing cows in acceptable condition.

New Mastitis Infections: Cows that milk faster have higher infection risk. Cows with more patent (slack) teat canals also have higher infection risk dur-

ing their dry periods. Thus, high-producing cows may have higher mastitis infection risk because of the indirect relationship between high production, high milking rates, and more patent teat canals (see review by Mein & Thompson, 1993).

Management practices to keep udders clean, such as clipping or "flaming" udders and use of clean bedding materials, and milking practices such as pre-milking teat preparation and post-milking teat disinfection, will require meticulous care and attention to detail to minimize the unavoidably higher risk of mastitis in high-producing, fast-milking cows.

Performance Guidelines for Milking Systems

A new national standard for the construction and performance of milking systems was published last year (ASAE S518: 1994). This new ASAE standard is based on a Draft International Standard, DIS/ISO 5707:1994, which has been reviewed and revised extensively during the past 3 years. Both standards incorporate new performance guidelines to provide a common basis for evaluating the great variety of types and sizes of milking systems used throughout the world.

The new performance guidelines for sizing milklines, vacuum supply lines, and vacuum pumps, are based on recent research at the UW-Madison. This research showed clearly that transient vacuum drops of less than 0.6" Hg in milkline or receiver vacuum had little or no effect on the normal cyclic vacuum changes in the milking clusters. Such small transient vacuum changes are completely lost, or over-ridden, by the larger cyclic changes generated within the cluster by the combined effects of pulsation and milk flow from the cluster.

The new performance guidelines are based on these conclusions: that transient vacuum changes of 0.6" Hg or less in the milkline or receiver are hardly measurable in the claw and have no significant effects on milking characteristics, mastitis, or milk quality.

Why choose an odd value such as 0.6" Hg for a national standard? Firstly because 0.6" Hg is equal to 2 kiloPascals (2 kPa) in the internationally-accepted SI unit of pressure. And, more importantly,

because vacuum fluctuations in the claw are usually increased whenever the milkline vacuum drops more than 0.6" Hg.

Sizing milklines: Fluid flow in milklines typically varies between "stratified flow" (when milk flows in the lower part of the milkline and air can flow in a clear, continuous path above the milk) and "slug flow" (when intermittent slugs of milk fill the entire cross-section of the milkline). Stratified flow is the preferred flow condition to maintain a reasonably stable vacuum supply to the cluster during milking. Slug flow conditions almost always induce a transient drop in milkline vacuum greater than 0.6" Hg. Transient vacuum drops caused by slug flow are characterized by a rapid drop in milkline vacuum below the average stable level in the receiver, and rapid recovery when the slug enters the receiver.

The key performance indicator of stratified flow, therefore, is that milkline vacuum should not fall more than 0.6" Hg below receiver vacuum, at the designed milk and air flow rates, including the transient air flows normally associated with cup changing and liner slips.

New recommendations for sizing milklines (Tables 1 & 2) are based on this performance guideline to ensure that stratified flow is the normal flow condition for milking high-producing cows in parlors or stanchion barn installations, now and into the next decade. It is important to remember that occasional slug flow will occur due to excessive air admission during cup changing or cup falling. Such transient vacuum drops associated with occasional slug flow will have little or no effect on milking performance, mastitis, cell count or milk quality unless they are severe enough to increase the incidence of liner slips and cup falling. The recommendations in Table 1 are for operators who take reasonable care to limit the amount of air admitted into the system during cup application and removal. The guidelines in Table 2 are more conservative for more typical operators. The differences between the two Tables implies that the milking staff play an important role in maintaining a high degree of vacuum stability in the milkline.

Table 1: Milking Parlors: looped milkline with units attached simultaneously by careful operators.

nominal line size	---- maximum no. of units per slope ----				
	0.8%	1.0%	1.2%	1.5%	2.0%
48mm (2")	2	3	3	4	5
60mm (2.5")	6	6	7	9	10
73mm (3")	11	13	14	16	19
98mm (4")	27	30	34	38	45

NOTE: A slope of 0.8% is equal to a 1-inch drop in 10 feet. A slope of 1.2% is equal to a 1.5-inch drop in 10 feet. Milkline slopes greater than 1.6% (2" drop in 10 feet) are not recommended unless the cow platform is sloped in the same direction as the milkline.

Table 2: Milking Parlors: looped milkline with units attached simultaneously by typical operators.

nominal line size	---- maximum no. of units per slope ----				
	0.8%	1.0%	1.2%	1.5%	2.0%
48mm (2")	1	1	2	2	3
60mm (2.5")	4	4	5	6	8
73mm (3")	9	10	12	13	16
98mm (4")	24	27	31	36	41

Sizing airlines: Differences in vacuum levels between the pump and receiver should not exceed 0.6" Hg. Higher readings, indicating greater vacuum drops, result in decreased air flow reserve at the receiver. Greater vacuum drops are influenced by small line sizes, too many Tees or elbows, or high air flows. Recommendations for sizing the main airline relative to pump capacity, line length and fittings are given in Table 3.

Vacuum fluctuations in the far end of the pulsator airline should not exceed 0.6" Hg. The current 3-A dimensional guidelines seem adequate: that is, 2" for up to 14 units, 3" for 15 or more. If 2" line is acceptable up to 14 units per side, then 3" should be acceptable for up to 32 units based on the simple ratio of the pipe areas. Therefore, 4" pulsator airlines could be used for systems with more than 32 units per side.

Differences in vacuum levels between the receiver and regulator should not exceed 0.2" Hg. Higher readings indicate higher vacuum differences which reduce regulator performance because of

either improper location, or excessive restrictions in pipelines and fittings between the receiver and regulator. The most common cause of low regulator efficiency is an excessive vacuum difference between the regulator and the receiver. Regulators mounted on branch lines often perform inefficiently unless the connecting lines are adequately sized to minimize frictional losses. Branch lines are fine as long as they are sized generously. Guidelines for sizing the regulator branch line are given in Table 4.

Regulators mounted on or near the distribution tank often tend to oscillate of the cyclic vacuum changes in pulsator airlines. Preferably, the regulator (or its sensor) should be connected near the sanitary trap so that it can sense, and quickly respond to, vacuum changes caused by "unplanned" air admission entering the system through the teat cups.

Reserve pump capacity: In 1992, Paul Blackmer (DVM, Veterinarians' Outlet, CA) proposed a practical performance criterion to demonstrate adequate vacuum pump capacity for milking:

Vacuum fluctuations in or near the receiver should not fall more than 0.6" Hg below the intended vacuum level during the course of normal milking (including cup attachment and removal, liner slips and cluster falls).

This proposal has been tested by a Task Team of the National Mastitis Council's Machine Milking Committee. The Task Team has just completed a two-part field study to determine the minimum Effective Reserve required to achieve an acceptable degree of vacuum stability during milking. Before describing the main conclusions and recommendations of the NMC Task Team, here's a brief explanation of the term "Effective Reserve" and some related indicators of the effectiveness of vacuum production and control:

- "Effective Reserve" is an airflow measurement of the spare (or "reserve") pump capacity actually available to maintain the receiver vacuum stable within 0.6" Hg when extra air enters the system dur-

Table 3: Recommended minimum pipe sizes (inches internal diameter) for main airline of a milking system.

Vacuum pump capacity	approximate length of main airline				
	10'	20'	40'	60'	80'
50 cfm	2	2	2	3	3
70 cfm	3	3	3	3	3
100 cfm	3	3	3	3	3
150 cfm	4	4	4	4	4
200 cfm	4	4	4	4	4
250 cfm	4	4	6	6	6
300 cfm	6	6	6	6	6
350 cfm	6	6	6	6	6
400 cfm	6	6	6	6	6

NOTES: The main airline is defined as the pipeline between the vacuum pump and the sanitary trap near the receiver. Calculations are based upon a maximum vacuum drop of 0.5" Hg between the receiver and the vacuum pump. This table includes an allowance for the equivalent length (feet of straight pipe) of one distribution tank, one sanitary trap and 8 elbows.

In systems with two receivers, the theoretical maximum air flowrate in the two separate airlines between the distribution tank and the sanitary traps may be halved. The size of these split lines could be reduced according to the values in the table corresponding to half the vacuum pump capacity.

Table 4: Recommended minimum pipe sizes (inches internal diameter) for the regulator airline, if installed.

manual reserve	equivalent length of regulator airline				
	10'	20'	40'	60'	80'
50 cfm	2	2	2	3	3
70 cfm	3	3	3	3	3
100 cfm	3	3	3	3	3
150 cfm	4	4	4	4	4
200 cfm	4	4	4	4	4
250 cfm	4	4	6	6	6

NOTES: The regulator airline is the branch line connecting the regulator to the main airline. These calculations are based upon a maximum vacuum drop of 0.1" Hg between the regulator and the main airline.

ing milking. The test assumes that a vacuum drop of 0.6" Hg is an acceptably small drop which has little or no effect on milking performance and which is sufficient to allow the regulator to close. It is measured with:

- All the teat cups plugged and under vacuum.

- The regulator connected and working.
- Air admitted into the receiver to drop the receiver vacuum by 0.6" Hg.

The NMC Task Team concluded (Mein et al, 1995) that:

1. All milking systems should have sufficient Effective Reserve (ER) to cover the possibility that at least one milking unit might fall off during milking. This implies a minimum ER of 35 cubic feet per minute (cfm) free air for any conventional milking system without automatic shut-off valves in the claw.
2. Larger systems (more than 32 units) should have sufficient reserve to cope with two simultaneous falls even though the likelihood of these events occurring simultaneously seems very low.
3. No system appears to need any more than 120 cfm Effective Reserve.
4. The suggested range of 35 cfm minimum ER and 120 cfm maximum ER will provide adequate reserve for vacuum stability during milking.
5. A simple formula for ensuring generous ER for systems with up to 80 units is: a basic reserve of 35 cfm, plus an incremental reserve of 1 cfm per unit.

"Manual Reserve" is a measurement of the airflow capacity potentially available to maintain the receiver vacuum stable within 0.6" Hg if the regulator could close completely. It is measured with:

- The regulator disabled (put out of action).
- All the teat cups plugged and under vacuum.
- Air admitted into the receiver to drop the receiver vacuum by 0.6" Hg.

In summary: Effective Reserve is measured with the regulator working. Manual Reserve is measured with the regulator disabled. The difference between these airflow measurements is "Regulator Leakage".

Another useful indicator of the effectiveness of the vacuum regulation system is the "Regulator Percent Closure" (also known as "Regulator Effi-

ciency").

$$\text{Regulator Percent Closure} = \frac{\text{Effective Reserve} \times 100}{\text{Manual Reserve}}$$

A Regulator Closure of 100% would mean that the regulator can close completely in response to a vacuum drop of 0.6" Hg below the working vacuum in the receiver. A good practical guideline is that Regulator Closure should be 90% or more. This guideline is the simplest practical indicator of the combined effects of the sensitivity of the regulator, the amount of reserve pump capacity provided, and the effects of airline sizes and other restrictions to air flow between the regulator and the site of measurement.

The efficiency of vacuum regulation can be improved on many installations. Regular cleaning and maintenance of the regulator is an important part of the solution. However, poor regulator performance often results from inappropriate regulator location combined with inadequate airline sizes to cope with excess vacuum pump capacity. The vacuum regulator should be moved and/or airline sizes and pump capacity adjusted to provide an Effective

Reserve of 90% or more of the available Manual Reserve (MR).

Guidelines for pump capacity are desirable for advisors and farmers. Assuming that ER is at least 90% of MR, a simple guideline for estimating the minimum pump capacity would be a basic reserve of 35 cfm, plus an incremental allowance of 3 cfm per unit. Such a guideline would provide enough pump capacity to cover allowances for system leakage, pump wear, and also regula-

tor leakage if the regulator is correctly located and adequately plumbed. However, extra pump capacity might be needed to allow for certain ancillary components during milking and/or washing (Mein et al, 1995).

These results provide broad support for the simple guidelines for pump capacity which were pub-

Table 5: Pump horsepower and number of milking units (from Bray, 1992), based upon 10 cfm per HP for oil or lobe pumps; 7.5 cfm/HP for water ring pumps.

HP	oil or lobe pumps (no. of units)	water pumps (no. of units)
5	1-5	1
7.5	6-12	2-6
10	13-20	7-12
15	21-35	13-24
20	36-50	25-35
25	51-67	36-47
30	68-80	48-57

lished by Bray (1992) and which are reproduced as Table 5 for convenient comparison. These guidelines will provide adequate airflow capacity for efficient cleaning of properly designed CIP systems (Figure 2, from Reinemann and Mein, 1995).

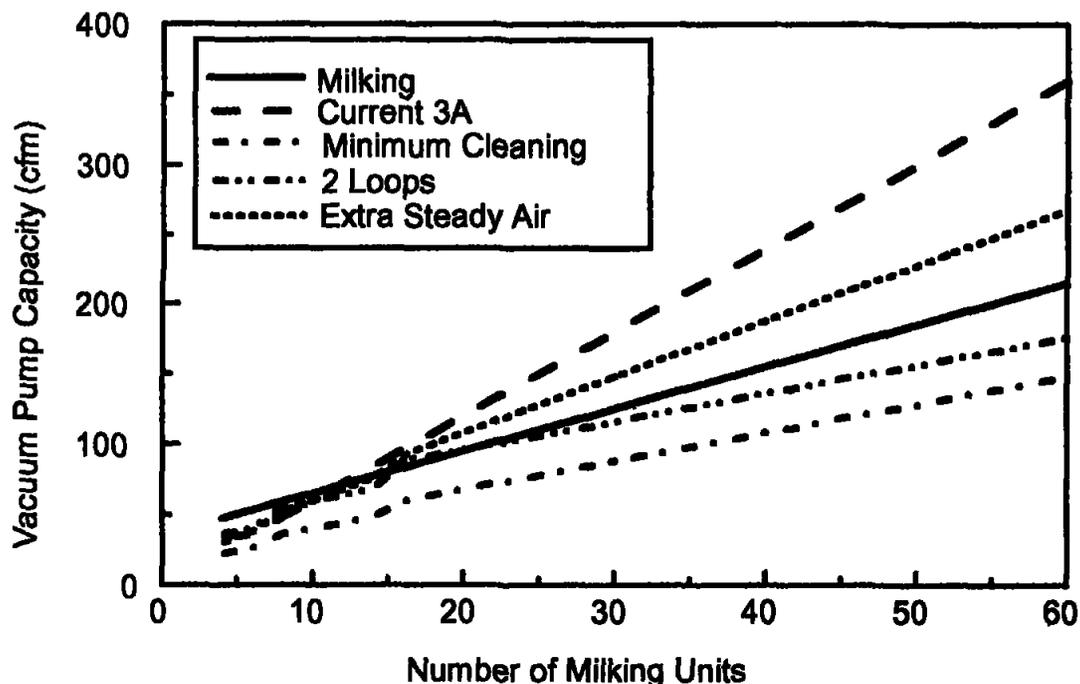
Compared with current 3-A Accepted Practices, these recommendations would provide higher pump capacity for systems with up to 8-10 units, similar pump capacity for 12 units, and progressively lower total pump capacity for systems with more than 16 units (Figure 2).

In the field study conducted by the NMC Task Team, improved system design produced big improvements in the effectiveness of vacuum regulation on most milking systems. Because of the improved regulator performance, the available pump capacity (and, therefore, the Manual Reserve) could be reduced by at least 50 cfm for 14 of the 19 systems, and by more than 100 cfm on nine of these

systems. Thus, significant energy savings were achieved on most farms with no evidence of reduced milking performance for any of the herds. If the cost of electrical energy is 10¢ per kWh, then the energy cost for a 10-HP pump running 18 hours/day is over \$500 per month (Table 4 in Mein et al, 1995).

An example of the effects of these design improvements on some dimensions, air flow capacities and wash water requirements, is given in Table 6 for a Double-24 parlor. There is strong evidence from laboratory research, field studies and experience on a wide range of commercial farms to support a revision of the current national standards for vacuum pump capacity. However, the process of review and possible revision of the 3-A Accepted Practices and ASAE S-518 Standards may take 12 months or more. In the interim, dairy farmers who wish to take advantage of the potential savings in

Figure 2: Vacuum pump capacity required for cleaning and milking. Milking requirements are from Mein et al. 1995. The minimum requirement for cleaning is one air injector open at any one time and 2 cfm per milking unit. The medium level for cleaning is for two air injectors open or two flow circuits with cycled air injection simultaneously and 2 cfm per unit. The maximum for cleaning is one air injector open and 4 cfm per unit.



energy and water use will need to seek permission for such variations from the relevant State regulatory authorities. Furthermore, because most milking equipment suppliers will be reluctant to install systems which do not meet current national standards, the owner should be prepared to sign a waiver that he/she wants a system with lower pump capacity.

Another interim option for large milking systems would be to install 2 pumps which, when run together, meet current 3-A standards and, when only one pump is running, would meet the new minimum requirements for Effective Reserve. If so, the second pump can be used as a stand-by in case of breakdowns.

Testing, Service & Maintenance Of Milking Equipment

Excellent new procedures for milking system evaluation have been developed by a Task Team chaired by Andrew Johnson, DVM, for the National Mastitis Council's Machine Milking Committee. In addition, a systematic visual check can indicate the milking machine faults likely to be associated with mastitis or teat condition problems, or with slow or incomplete milking. Guidelines for the three best indicators of machine function during milking are given in the 1992 NMC proceedings (Mein, 1992). They are:

- The condition of teats when cups are removed.
- The completeness of udder evacuation.
- The frequency of slipping or falling teat cups.

The most common reason for milking system problems in the 1990's is inadequate routine maintenance of milking equipment. The booklet "Maximizing the Milk Harvest" (MMMC, 1993) makes a

Table 6: Comparisons of current accepted practices with new performance guidelines for a double-24 milking system without milk meters.

	current practices	adequate for efficient milking and cleaning with good design
min. vac. pump capacity	290 cfm (3A, 1990)	180 cfm (Mein et al, 1995)
motor power; all or lobe (⊙ 10 cfm/HP)	30 HP	20HP (from Table 5)
motor power, water ring (⊙ 7.5 cfm/HP)	40 HP	25 HP (from Table 5)
milklines	2 x 4" loops (3A, 1990)	2 x 3" loops (from Table 2) (slope of 1.5" per 10')
manual reserve (estimated by assuming 2 cfm used per unit)	194 cfm	84 cfm
effective reserve	78 cfm (with 40% regular closure)	76-80 cfm (with 90-95% regular closure)
pump capacity required for C.I.P. cleaning	240-290 cfm (5-6 cfm/unit)	124-152 cfm (from Figure 2)
water used per wash cycle	212 gallons	85 gallons (Reinemann & Mein, 1995)

simple analogy: "A car driven at 60 mph for 10 hours per day will travel more than 200,000 miles in one year. Milking equipment, like the car, has many moving parts that wear over a period of time." The lack of down-time for maintenance in large dairies, combined with the lack of awareness of the gradual deterioration of components used for 10 or 20 hours per day results in a poor level of maintenance on many farms.

The MMMC booklet gives simple, clear guidelines for maintenance of milking and cooling systems. All milking machine companies and most milking equipment dealers have similar guidelines and most of them will provide service contracts for scheduled maintenance. Starting in 1990, member companies of the MMMC have developed a Certification Program for their technical staff and dealers to ensure that training courses conducted by individual companies contain the same minimum requirements. These training courses will, or should, include specialized training in the new concepts for improved system design and performance outlined in this paper.

With improved system design, some of the poten-

tial savings from reduced energy costs, water and cleaning chemical costs could be invested profitably in more thorough routine maintenance of equipment and facilities. That would be a "win-win" for all participants: dairy farmers, milking staff, equipment manufacturers and dealers, and for the cows!

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notes

Making Manure Nutrient Management Work For You

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Crop nutrient management is not a new idea. In fact, the concept dates back quite a few years. The idea is being revisited by dairy producers for two key reasons. The first is economics. It costs money to purchase and apply nutrients (fertilizer) for crop needs. The second reason to revisit crop nutrient management is the potential contribution of manure nutrients to ground or surface water contamination.

It is important to realize that nutrient management assumes a few points. One area relates to the application of nutrients. It is assumed that nutrients are applied at the appropriate time with respect to growth and development of the plant. It is assumed that nutrients are applied in a form available to the plant. Some forms may be more readily available than others. It is assumed that the appropriate amount of nutrients is applied. The second category of assumptions deals with the location of the nutrients. It is assumed that the nutrients are applied where needed. It is assumed that the nutrients are not leached beneath the root zone of the plant. This last assumption requires consideration of irrigation water management.

The areas of manure nutrient management considered here include: how to sample manures, what to do with the laboratory results, consideration of irrigation uniformity and efficiency, and how to develop a farm nutrient management plan.

Sampling Liquids

Knowledge of your pond nutrient content is the first step in making liquid manure nutrients work for you. The nutrient content of water in a dairy pond depends on the number of animals contributing to the pond, the presence or absence of a solids separator, the amount of fresh water added daily, and the amount of manure collected from each animal.

There is no rule of thumb to account for the nutrients in manure waters. In fact, data from the western states indicate large variations in nutrient content of manure waters. Total nitrogen in an acre-inch of water was 28 lbs from one pond and 228 lbs. from another pond (Morse & Schwankl, 1995). A similar comparison from multiple ponds sampled in

Idaho indicated average total nitrogen to be 83+60 lbs per acre-inch of water (Ohlensehlen et al., 1993).

It is critical to sample pond water to more closely estimate nutrient content. Sampling containers should be clean and dry. A sample should be more than a pint and less than a quart. Water should be flowing for at least 10 minutes before sampling. Fill the container about two-thirds full. Freeze the sample immediately after sampling. The empty air space in the container will allow the water to expand without breaking the container. Check with your analytical laboratory to determine the proper sample size, and particular handling practices for the sample. Labs may have sample containers for use.

It is easiest to sample water as it comes out of the pond and drops into the irrigation system standpipe. In fact, it is more precise to estimate nutrient content from manure water leaving the pond than it is to sample water in the pond. In some instances, it is not easy to access manure water as it enters a standpipe. If that's the case, sample manure water as it enters crop fields. When sampling at an irrigation valve (instead of a standpipe) it is important to let debris in the pipeline pass through, and to be sure the water being sampled is full strength manure water (not diluted).

Manure water should be analyzed from a pond during the spring dewatering. These waters can be different than waters used during the summer months. The results of samples taken on the same day are similar. Yet, results of samples taken on different days are quite different. At this time, the recommendation is to sample the manure water every other day during the spring dewatering. The average of the results should be used to estimate nutrient content of manure water.

Additional samples should be taken at least twice during the summer irrigations. If irrigation water is added to the pond, further sampling is recommended. This will improve the precision of estimating the nutrient content of the manure water. For instance, the nutrient content of the pond is reduced (diluted) when irrigation water is added.

Sampling Solids

The number of samples needed to estimate the nutrient content of solid manure depends on the amount and variability of the manure. Similar nutrient content of manures will come from animals of similar dietary nutrient intake. The nutrient content of manure from growing heifers, lactating cows and dry cows will differ. Also, the nutrient content of solids from a solid separator will be much different than the nutrient content of corral scraped manure. The important part of sampling is that the sample represent the source.

Using Laboratory Results

Often liquid samples are analyzed for total nitrogen, ammoniacal nitrogen, phosphorus, potassium, and salt (if a concern). All nutrients present are not readily available to plants. Phosphorus, potassium and salts are usually in a plant available form. Ammoniacal nitrogen (NH₄-N) can be rapidly converted to nitrate (NO₃) in the soil. Nitrate is the plant available form of nitrogen. In this sense, ammoniacal nitrogen is a fast release nitrogen and organic nitrogen is a slow release nitrogen source. The total remaining organic nitrogen can be converted to NO₃ over time (usually years). Also, the NH₄-N can be volatilized into air as ammonia. The percent volatilized depends on air and soil temperatures, soil conditions, amount of standing water, wind speed, and pH of the material. Few researchers are measuring the percent of nitrogen volatilized from land applied manure waters. It is assumed that 10% of NH₄-N is volatilized during land application with a range between 5 and 25%.

Some elements on a lab report are reported in units of parts per million. Parts per million can be converted to pounds per acre-inch of water by multiplying the value by .2268. Elements expressed as percentages can be converted to pounds per acre-inch of water by multiplying the value by 2268.

It is more precise to estimate nutrient content from manure water as it comes out of the pond and drops into the irrigation system than it is to sample water in the pond.

Some nutrients (calcium, magnesium, sodium, chloride) may be expressed as milli-equivalents. These need special conversion factors. The laboratory supplying the analysis can assist you with appropriate conversions.

The next step is to calculate manure water flow. After that, it is a simple conversion to go from pounds per acre-inch of water to pounds per acre of field. Pumping rate of the manure water must be known.

Determining pumping rate is easier said than done. Usual farm

pump tests seldom include checking manure pumps. One challenge of getting a manure pump test done is the fact that manure water isn't clean and therefore it dirties the individual attempting to install a metering device. Also, manure water has debris (straw, leftover feed, gloves, etc.) that will clog a typical propeller or turbine flow meter.

A non-invasive doppler meter can be used to measure flow rates. A sensor is strapped to the outside of the pipe and an ultrasonic signal is passed through the pipe. The signal is reflected by suspended particles in the fluid and the frequency shift in the signal is used to determine the velocity of the flowing liquid. Flow rate can then be calculated with the flow velocity and the pipe size. These meters are expensive, but may be owned by someone at the irrigation district, the electric company, or at your Cooperative Extension Office. Pump testing of manure ponds should be done when the pond is at various depths as the depth of water in the pond alters the pumping rate.

It's easy to calculate nutrient flow after the sample results are received from the lab and the pump test results are known. The calculation is as follows:

$$\begin{array}{l} \text{nutrients applied} = \text{nutrient content} \times \text{water applied} \\ \text{(lbs applied)} \qquad \qquad \text{(lbs/ac-in)} \qquad \text{(acre-inches)} \end{array}$$

Water applied can be calculated by multiplying the flow rate (gallons/minute) by the amount of time the water flowed (number of minutes) divided by 27,154 gallons per acre-inch of water. For a pump that discharges 300 gallons/minute the calculation for 2 hours (120 minutes) is $300 \times 120 / 27154 = 1.3$ acre-inches. The nutrients entering the field are divided by the amount of acres to determine the pounds of nutrients applied per acre of cropland.

An example of nutrients (pounds) applied to a field during a one-hour irrigation are in Table 1. After 1 hour of pumping with a 100 gallons per minute pump, and a nutrient content of 100 parts per million, 5 pounds of the nutrient entered the field. If the pump rate was 500 gallons per minute and the nutrient content was 100 parts per million, then 25 lbs of nutrients would enter the field. Note: these calculations are for a pump working 1 hour. Most irrigations are more than 1 hour.

Results from solid manure samples are similar to forage test results. Moisture and percentages of each element will be listed.

Total nitrogen will be reported. Unless requested, ammoniacal nitrogen will not be reported. A useful calculation is to determine the amount of nutrient applied per ton of wet manure applied.

Irrigation Efficiency And Uniformity
Once nutrient content (lab analysis) and application rate (pumping rate

for liquids, spreading rate for solids) are known, the next step is to determine where nutrients are going. Nutrients in manure water follow the water flow. Although a considerable amount of solids can settle out during an irrigation, nutrients don't settle out (Morse et al., 1994).

It is important to identify how much and where water goes during an irrigation. Irrigation water applied to a field can end up in one of three locations. The desired location is for water to be stored

in the crop's root zone. Storing water in the crop's root zone is the normal objective of an irrigation. Irrigation water can run off from the field surface. Tail water return systems can be used to capture surface runoff and reuse it. Other surface runoff is illegal in California. Another location where water may end up is below the crop's root zone. Excess water results in deep percolation. Both water and nutrients move beneath the crop's root zone. Nitrate is very mobile in soil and moves with the deep percolating water front. These losses are undesirable as more water is used than needed and leached nutrients may contaminate groundwater.

Irrigation efficiency describes how much of the applied irrigation water is stored in the crop's root zone. This number expresses the amount of water used by the plant as a percent of the water applied. The formal definition of irrigation efficiency (IE) is:

$$\text{Irrigation Efficiency (IE-\%)} = \frac{\text{water beneficially used}}{\text{water applied}} \times 100$$

Beneficially used water is the amount of water

needed to refill the crop's root zone. This amount of water is equal to the soil moisture used by the crop since the last irrigation. Irrigation scheduling techniques can be used to determine the irrigation amount required. These techniques include determining plant evapotranspiration (ET) and/or soil moisture monitoring. For instance, if the last irrigation was 10 days

ago, ET estimates may indicate that the crop used 2.5 inches of water (0.25 inches/day x 10 days = 2.5 inches). The objective of irrigating would be to apply 2.5 inches of water to refill the crop's root zone.

Irrigation Application Uniformity

Water application uniformity describes how evenly water is applied to the field. If every part of

Table 1. Amount of nutrients applied to a field (pounds) based on nutrient content of water (parts per million-ppm) and pump rate (gallons per minute-gpm). This assumes the pump ran for 1 hour.

nutrient content (ppm)	100 gpm	300 gpm	500 gpm
25	1	4	6
50	3	8	13
100	5	15	25
150	8	22	38
200	10	30	50
250	13	38	63
300	15	45	75

the field received the same amount of irrigation water, the irrigation would be 100% uniform.

Distribution uniformity (DU) is commonly used to quantify uniformity in furrow and border irrigation systems. It is defined as:

$$\text{distribution uniformity (DU-\%)} = \frac{\text{depth of water applied to low } 1/4 \text{ of field} \times 100}{\text{average depth applied}}$$

The depth of water applied to the low 1/4 of the field is the depth of water applied to the 25% of the field which receives the least water. For furrow-irrigated fields, this is usually the 25% of the area at the tail end of the field.

Irrigation water application rate should be determined. Measuring manure water quantities was dis-

cussed previously. The contribution of clean irrigation water can be determined. Pump test results from a well can be used to estimate flow rates. Realize these estimates can lead to errors as changes in pump performance, pumping depth, etc. can change pump rate. A more precise method of determining well water flow rate is to use an in-line meter (e.g. propeller meter). Additionally, flow rate should be determined for canal water.

Interactions Between Irrigation Efficiency And Uniformity

Understanding the relationship between irrigation efficiency and uniformity is the key to understanding good irrigation water management. It is not possible to adequately irrigate a field efficiently (the appropriate amount of water) unless the water is applied uniformly. However, irrigating uniformly will not guarantee that the irrigation is efficient.

Efficiency - How much of the applied irrigation water goes to the crop.

		Good	Poor
Uniformity- How evenly irrigation water is applied to the field.	Good	<p>Desired</p> <p>Minimal hazard to groundwater.</p>	<ul style="list-style-type: none"> ● Practice irrigation scheduling to prevent over-irrigation of the crop. ● Measure irrigation flow rates. ● Use tailwater return system to reduce tailwater runoff problems.
	Poor	<ul style="list-style-type: none"> ● Under-irrigation - practice irrigation scheduling. ● Use higher irrigation flow rates to the field. ● Reduce or eliminate deep soil ripping. ● Use tailwater return to ensure adequate irrigation of the entire field. ● Consider shortening the field to improve the irrigation uniformity. 	<ul style="list-style-type: none"> ● Over-irrigation - practice irrigation scheduling. ● Measure irrigation flow rates. ● Use tailwater return system to reduce tailwater runoff problems. ● Consider shortening the field to improve irrigation uniformity. ● Use higher irrigation flow rates to the field, but need to adjust irrigation set times in accordance. ● Use furrow torpedoes for early irrigations. ● Reduce or eliminate deep soil ripping. ● Consider use of surge irrigation. ● Increase the field slope to increase the irrigation water advance rate.

Fig. 1. Management practices to improve irrigation efficiency and uniformity.

Potential of contaminating groundwater by deep percolation from manure water irrigations will be affected by:

- (1) the irrigation water nutrient concentration;
- (2) the chemical form of nitrogen in the irrigation water;
- (3) soil characteristics such as permeability, porosity, and texture; and
- (4) soil nutrient levels prior to irrigating. Information is not available currently to predict the nutrient content of deep percolating water resulting from a single irrigation event.

Management Measures To Improve Irrigation Practices

The following scenarios illustrate the combinations of irrigation efficiency and uniformity. Management alternatives are provided to reduce the risk of contaminating groundwater. Each of these scenarios has a potential impact on groundwater quality. The extent of contamination will depend on the amount of deep percolation and the nutrient content (e.g. nitrate). The fourth combination – good efficiency and good uniformity – is the desired irrigation event. A summary of management alternatives to minimize groundwater contamination is in Figure 1 on the preceding page.

Irrigation Uniform But Inefficient

Scenario 1 is an irrigation which is uniformly applied, but is inefficient. In this case, the irrigation system is performing acceptably. Water is uniformly distributed. However, water is not used efficiently. Irrigation scheduling is not being practiced and/or water quantity is not being measured. Excess irrigation water is being applied. Over applied water will result in deep percolation. Both soil and manure water nutrients can move downward with the deep percolating irrigation water.

Irrigation efficiency can be improved to decrease the amount of deep percolation. One method to improve efficiency is to decrease the amount of water used in an irrigation. Another method is to increase the interval between irrigations. Either alternative should more closely match the soil moisture used since the previous irrigation. Usually, it is more practical to increase the interval between irrigations. Frequently a minimum amount of water must be applied for the water to advance across the field. An alternative management technique may be to match

the minimum water application amount with the corresponding irrigation interval. Crop water use would be equivalent to the irrigation amount needed to advance water across the field.

A fourth alternative to improve irrigation efficiency is to collect and reuse tail water runoff from the field. Tail water return systems allow use of large flow rates and can help ensure that the tail of the field is adequately irrigated. The adoption of irrigation techniques to avoid tail water runoff – small flow rates, long field lengths, etc. – can lead to inefficient and non-uniform irrigations. Substantial deep percolation at the head of the field is a common result, and inadequate irrigation at the tail of the field is also common.

Irrigation Efficient But Non-Uniform

Scenario 2 is an irrigation which is efficient but non-uniform. On the average, the correct amount of water is applied to the field (it's efficient). For example, if 3 inches of water have been depleted from the soil profile by crop water use, for each acre irrigated, 3 acre-inches of water would need to be applied. For furrow irrigation, the non-uniformity usually results in the head of the field being over-irrigated while the tail of the field is under-irrigated. The over-irrigation (inefficient) at the head of the field would produce deep percolation. The deep percolation could move soil and manure water nutrients into underlying groundwater. Thus, even though on the average the correct amount of water was applied, the application non-uniformity would result in deep percolation. The irrigation system application uniformity must be improved in order to adequately irrigate the entire field while irrigating efficiently. Alternative practices to improve uniformity are included in the next section.

Irrigation Inefficient And Non-uniform

Scenario 3 is an irrigation which is inefficient and non-uniform. Such an irrigation results from excess use and uneven distribution of water. This scenario holds the greatest potential for deep percolation and contamination of underlying groundwater.

This scenario occurs when the field length is too long to irrigate uniformly. Also, irrigations on soils

with poor water holding capacity are often inefficient and non-uniform. Only a small amount of water per irrigation is needed to refill the crop's root zone. Such conditions exist when sandy soils are irrigated. Such soils don't store much water and need small yet frequent irrigations.

The major criterion for determining irrigation set time is the amount of time it takes to get water to the end of the field (advance time). The minimum depth of water which can be applied per irrigation is controlled by the end-of-field advance time. For example, if corn irrigations are at 10-day intervals, the irrigation objective may be to apply 3 inches of water during the irrigation. This objective would result in an efficient irrigation. The length of the field requires application of a minimum of 5 inches of irrigation water simply to advance water to the end of the field. The result is an irrigation event which is inefficient (over-irrigated).

Irrigation non-uniformity is a result of the different lengths of time water is in contact with the soil (infiltration time) at various parts of the field. For example, a typical, 800-foot, furrow-irrigated field may require 8 hours to advance water to the end of the field. The irrigation water is shut off when it reaches the end of the field. Water therefore infiltrates for 8 hours at the head of the field and for only a few minutes at the tail of the field. This difference in infiltration time results in significantly more water soaking into the soil at the head of the field than at the tail of the field. Irrigation non-uniformity is the result of such an irrigation.

Furrow and border irrigation often suffer from such an irrigation non-uniformity problem. There will always be a difference in infiltration time between the head and tail of the field resulting from the time it takes to advance water across the field. Shorter field lengths have lesser infiltration time differences between the head and tail of the field. This results in better irrigation uniformity.

Alternative management practices can improve the irrigation system's application uniformity. Physical changes require capital expenditures. The costs and benefits (water and nutrient conservation) need to be evaluated for each alternative. The following

alternative practices may be used to improve application uniformity.

- Change the field slope. Increasing the slope of a field will cause water to advance across the field more quickly. This will reduce the time water is allowed to infiltrate at various field locations.

- Increase the water flow rate to the field. This will result in faster water advance across the field and reduce the time water is allowed to infiltrate.

- Reduce deep ripping of the field or alter season of deep ripping. Deep ripping prior to field preparation and irrigation results in an increased infiltration rate and a slower water advance time down the field. The slower water advance results in greater irrigation non-uniformity. Eliminating deep ripping altogether or minimizing its use can reduce the severe irrigation non-uniformity problems often experienced during the pre-irrigation and early season irrigation events. There is no capital cost associated with reduced deep soil ripping.

- Use furrow torpedoes. Furrow torpedoes are weighted steel cylinders, 6 to 12 inches in diameter and up to 4 feet long. Torpedoes are dragged in furrows to break up soil clods and smooth the furrow surface. They are most effective when used prior to the pre-irrigation or following field cultivation. The result is more rapid irrigation water advance and improved irrigation uniformity.

- Use surge irrigation. Surge irrigation is turning water on and off as it flows down the field. Water is allowed to flow down the field for a given distance. The flow is stopped until the water in the furrow recedes. The water flow is restarted. This can result in less water being used to advance the irrigation water to the end of the field. During the off-time, the flow can be diverted to other parts of the field. The second water surge wets both the previously wetted length of the furrow and an additional section of dry soil. This procedure continues until water reaches the end of the field. Use of surge irrigation can improve the irrigation application uniformity as well as the irrigation efficiency. While surge irrigation can be done manually, automation requires a surge valve and gated pipe.

- Reduce the field length. This is the most effective step which can be taken to improve irrigation uniformity, but it is also very expensive. The costs, such as new supply pipeline and re-leveling, can make reducing field lengths impractical.

Nutrient Management Program

Two final pieces of information are needed before a nutrient management plan can be developed. Soil nutrient content and estimated plant nutrient use should be known. The number of soil cores needed to determine soil nutrients depends on field variability. Contact the local Cooperative Extension Office or Natural Resource Conservation Service (formerly the SCS) for advise on soil sampling. They can also aid you in determining the depth of the sampling. Certainly, one needs to sample through the depth of the crop root zone. You may chose to have soil samples taken by a private lab.

Plant nutrient use can be determined in one of two ways. One method is to determine the amount of nutrients harvested the previous cropping season. This is easy to do when a forage crop was grown and harvested. Yields and nutrient content would be available. Another method is to use recommended nutrient requirements for crops where all the plant matter isn't harvested, or it is harvested but not analyzed for nutrients. Nutrient needs of cotton or cereal grains are best determined from local data or standard tables for your county or state.

Now actual nutrient management plan can be developed. For each field, the following calculations should be made. Amounts of nitrogen, phosphorus and potassium needed by the plant and present in the soil should be estimated. By difference, the approximate amount to apply is calculated. The actual amount of nutrients supplemented may be more than what is calculated. This would allow for nitrogen lost to the atmosphere that is not available to the plant.

If line 3 is greater than 0, then the land can accept manure nutrients. Other items to consider in a nutrient management plan include when to apply nutri-

	Tons	N	P (lbs/acre)	K
1. Est. crop yield	_____	___	___	___
2. Avail soil nutrient contribution		___	___	___
3. Add'l nutrients needed (line minus line 2)		___	___	___

ents, soil nutrient and water holding capacity, and soil type.

Realize that if manure nutrients are applied to meet the nitrogen needs of a crop, phosphorus, potassium and salts are usually over applied. This can lead to an undesirable buildup of salts in the soil. Although deep percolation is a standard practice to remove excess salts from the crop root zone it will result in salts leaching into the underlying groundwater. Also, phosphorus is not easily leached through the soil, but can be a concern related to surface water quality. Phosphorus enters surface waters when soil is eroded.

Additional nutrients needed can be obtained through a variety of sources: irrigation water, manure water, solid manure, other soil amendments or commercial fertilizer. The application rate of manure nutrients should depend on the nutrients needed. the soil nutrient needs should be used to determine if the land can accept manure nutrients and at what rate the nutrients can be applied. Once this is calculated, then the manure application rate is determined.

The limiting nutrient to determine manure application rate will vary. If surface water concerns exist, phosphorus usually limits application rate. If groundwater concerns exist, nitrogen or salts may determine application rate.

Producers who live on poor soils and have high water tables must be particularly careful with nutrient applications. Such locations are more susceptible to groundwater contamination. Excessive irrigation water use can be detrimental. Both nutrient management and water use must be managed to prevent contamination of groundwater.

The biggest question arises when nutrient management plans are developed and it is evident that insufficient land exists to utilize manure nutrients. When this occurs there are other alternatives. The

appropriate combination of alternatives will depend on the magnitude of the extra nutrients and which nutrients are excessive.

A successful nutrient management plan will monitor nutrients applied to soil as well as nutrient movement through the soil. Irrigation water management is a critical element to nutrient movement in the soil.

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notes

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Freestall Housing Guidelines: Design Details To Enhance Management

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A well planned housing design provides the dairy herd with good access to feed and water, a clean, dry, comfortable resting area, and good ventilation during all seasons. Whether one group or a dozen, good system planning simplifies the process of milking, animal handling, feed delivery and manure collection so that these tasks may be performed properly and consistently. Good design can save time, minimize the amount of labor required and reduce drudgery and frustration. This paper will focus on design details that enhance cow comfort and make the movement of animals, feed, and manure more convenient in dairy freestall housing using fenceline feeding.

Clean, healthy, high producing cows require four basic things from the housing area:

- 1). *Clean, dry, comfortable resting area.*
- 2). *Good air quality.*
- 3). *Good access to (and a supply of) feed.*
- 4). *Good access to (and a supply of) water.*

Most other things done in the design of dairy housing are done for the manager, such as:

- 1). *Simple animal handling and observation.*
- 2). *Simple animal isolation and restraint.*
- 3). *Easy feed delivery.*
- 4). *Easy waste collection and removal.*

The designer should not compromise the cow's requirements in the layout of a housing system. Careful attention to cow comfort is necessary for good production, animal health, and to promote cow cleanliness.

Of course, the building should be located on a relatively level, well-drained site with a good source of potable water. Access for feed delivery and milk hauling should be convenient. Service roads around the dairy system should be suitable for traffic at all times of the year. Animal housing and manure storage areas should be located downwind and at a reasonable distance away from the residences to reduce odor and insect concerns. Allow adequate space for expansion. Assume that the dairy system will double in the future.

Animal Handling And Movement

Freestall housing systems allow cows to be man-

aged and handled in groups. These groups are moved to, through and from the milking center two or more times per day. However, individual cows must be separated from the group regularly for breeding, treatment or special observation. While cows are in the housing area they must have convenient access to feed, water and the resting area.

Each cow group should be moved to and from the milking center at a comfortable, easy pace, without excitement or unnecessary force, safely, by one person. In addition, the means to isolate and restrain an individual cow for special care should be provided to the handler.

Grouping

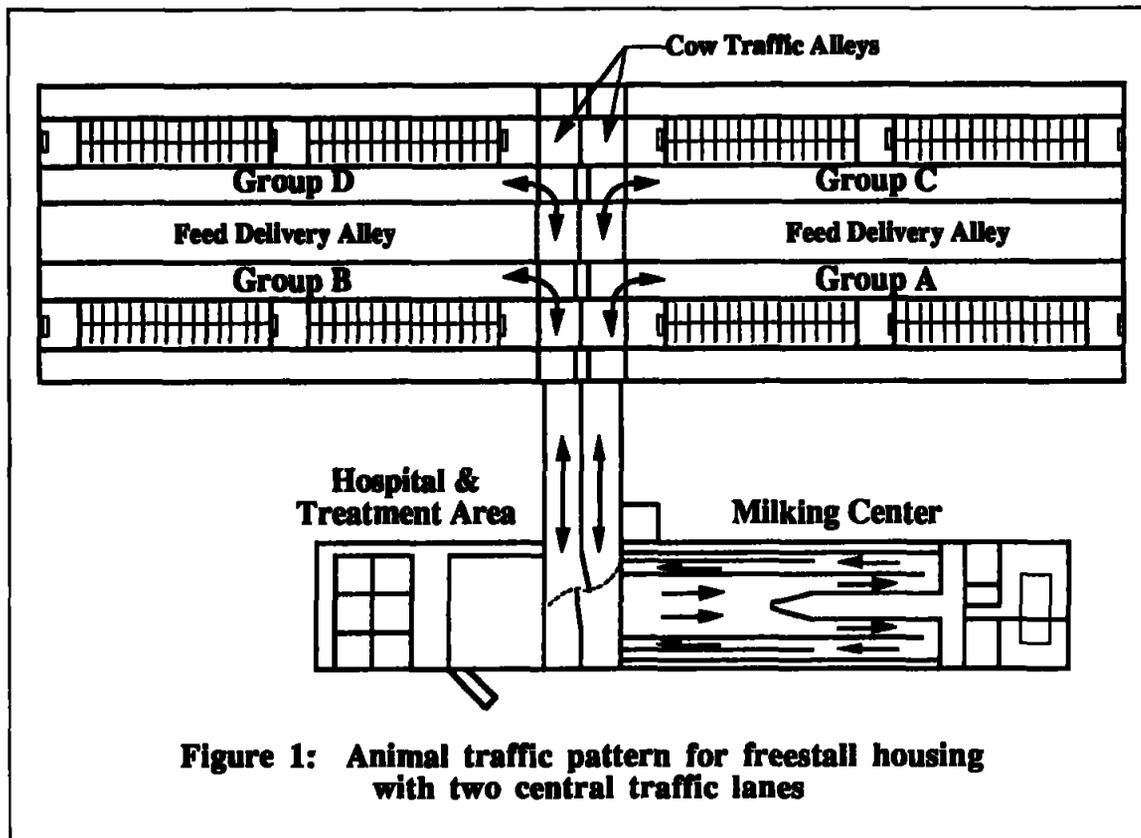
Dividing the milking herd into groups allows for better management. Grouping can simplify animal movement, make observation easier, and allow feed rations to be adjusted to fit the group's needs. Grouping of the milking herd is often done according to production, stage of lactation, or age.

The holding area should be large enough to confine each group so that cows do not have to be sorted, or enter the holding area in shifts. Sizing the holding area 25% larger allows another group to be moved into the holding area behind the crowd gate just before the other group is finished milking.

Group size is influenced by the capacity of the milking parlor. Armstrong (1993) suggests that cow groups milked two, three, and four times per day should be milked in 60, 45, and 30 minutes per group, respectively. This recommendation is based on the stress associated with a closely confined group of cows, especially in hot weather. Being away from feed and water for a long period of time is also a concern.

Albright (1983) suggests that group size remain stable and no larger than 100 cows. Each group should be identified clearly by name or number. This can be accomplished with a sign and/or blackboard located for convenient observation. Identification and information should be presented in a way that new/temporary employees can understand easily.

Traffic Lanes And Patterns



Making group movement and traffic patterns simple, with a minimum of turns and direction, changes will reduce frustration and excitement. Remember that given the chance, a cow will usually go the wrong way (Graves, 1986). The skill level and temperament of cow handler(s) should also be considered.

Traffic lanes between the housing area and milking center should have a well drained, non-skid surface which provides confident footing for cows during all types of weather. Lanes should not slope more than 6% in the direction of cow flow.

Traffic lanes should be wide enough to accommodate the group being moved. Traffic lanes should be 12'-16' for groups less than 150 cows and 20' wide for groups of 150 cows or more (Welchert, 1992).

The movement of one cow group must not interfere with another. Layouts which require one group to pass through the housing area of another group are not desirable. These arrangements may save

building space, but animal movement is usually more complicated, and a group may be restricted from the resting and/or feeding area(s) for a long period of time.

Traffic lane arrangements which allow a group of cows to move to the milking center while another is returning is preferred. Cows tend to linger on their trip back to the housing area from the milking center. Frustration may be increased, and animal movement is delayed, if the cow handler must chase cows out of the traffic lane before the next group can be moved. A second traffic lane allows the handler to briefly close the return lane(s) from the milking center and move the group into the holding area.

Figure 1 shows one layout for freestall housing with four groups. With proper gating, two traffic lanes near the middle of the building allow two groups to be moved without interfering with one another. Cattle guards and/or automatic gates can be used where animals and vehicle traffic cross.

Another layout alternative which provides sim-

ple cow movement is described in Figure 2. Groups are simply moved to, through, and from the milking center in a circular pattern.

Cow Alleys Within The Housing Area

The alleys in the housing area should allow the cows to move freely between the feeding, watering, and resting areas without interfering with other animals. Preferred alley widths at various locations in the housing area are shown below.

	minimum	preferred
Feeding area:		
feed barrier to rear of freestall	12'	14'
feed barrier to front of freestall	10'	12'
Resting area		
rear of freestall to wall	8'	10'
rear of freestall to rear of freestall	8'	10'

Animal Movement Within The Group

Cows within a group should be allowed easy and convenient access to the feeding area, resting area and water. More study needs to be done to find the optimum distances a cow should move between these areas. Some observation indicates that a crossover lane from the resting to the feeding area should be provided every 60'-80', or a row of 15-20 freestalls. Each crossover should contain a waterer and be wide enough, say 10'-12', so that cows using the waterer do not block the lane.

Floor And Traffic Lane Surfaces

All surfaces that cows come in contact with should provide a confident, non-skid footing. A floor surface

that provides confident footing reduces the chance of serious injury caused by slipping and falling. Cows are also more likely to mount and show signs of heat in a housing area with a good, non-skid floor surface.

Grooving is a common method for creating an acceptable floor surface. Grooves should be approximately 3/8"-1/2" wide and 3/8"-1/2" deep. The preferred pattern is a diamond shape where the grooves are placed 6"-8" on center. Parallel grooves 2"-4" on center are also commonly used in scrape alleys, traffic lanes and holding areas. Grooves should not run perpendicular to the direction of scraping.

Before animals are allowed onto the surface all sharp edges, or 'wickers', should be removed by chipping or grinding. If the surface is comfortable

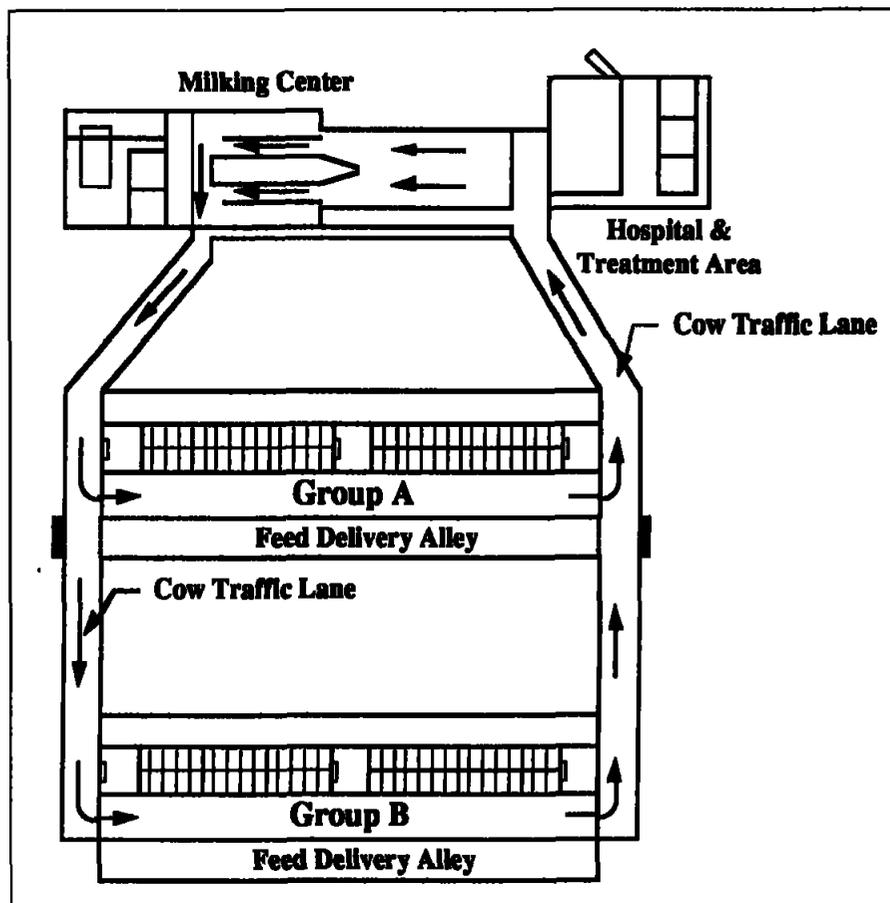


Figure 2: Animal traffic patterns for freestall housing with circular flow.

enough to walk in bare feet, it is probably acceptable for dairy cows (Graves, 1993).

In high traffic areas where cows may be moving and/or turning in groups, a surface with good traction is essential. In the milking parlor the floor surface is usually wet and must be easily cleaned. An anti-slip grit such as aluminum oxide can be troweled into the concrete after floating (Welchert, 1992). Installed properly, these surfaces provide an excellent non-skid surface which is easy to clean and durable. However, due to the abrasive nature of the grit, there is some concern about the amount of wear it may cause to the hoof if the cow is exposed to this floor surface continuously.

Separation, Isolation And Restraint

Individual cows must periodically be separated from the group for breeding, treatment, or special observation. A single handler should be able to isolate and restrain a cow with relative ease. Much of this process is based on animal behavior. Therefore, the handler should be familiar with the best and easiest methods for encouraging cows to move. Headlocks in the housing area and sorting lanes in the milking center can make this task much simpler.

Cows may be separated from the group easily as they exit the milking parlor. Cows are usually in single file in the return lane and can be sorted using a power operated cutting gate. The cutting gate may be controlled manually from the operator's pit in the milking parlor, or automatically by a transponder and identification arch. Catch lanes typically run parallel to the return lanes and can hold several cows briefly for observation. A headgate at the end of the lane provides simple restraint. Proper design of gating and pass-throughs in the catch lane allow the operator complete and convenient access to the restrained animal. A room/office adjacent to this area for the storage of breeding supplies, veterinary care products and instruments, and records is highly recommended. Hot and cold running water should also be available nearby.

A hospital/treatment area is necessary for cows requiring more rigorous examination, or longer term treatment or observation. This area should be sep-

arate from the housing area and milking center. The hospital/treatment area should provide the space and apparatus necessary to restrain a cow properly for examination and treatment, elevating and suspending feet, lifting downed cows, and surgery.

At least one treatment pen should be provided for every 50 cows (Graves, 1983). Each pen should be a minimum of 12'x12' (16'x16' preferred) and allow simple animal restraint and support, convenient access (for both handler and cow), easy clean out and downed animal removal, access to feed and water, and contain a non-skid floor.

Animals are transported regularly. An area designed to accept and isolate animals coming into the herd and load animals leaving the herd is desirable. A loading chute or dock of convenient height for the truck(s) used should be provided (Graves and Light, 1980). A durable, non-skid surface is necessary in the loading area.

Ganglock, or self-locking, stanchions are commonly found along the feed manger in many dairy enterprises using fenceline feeding. Some stanchion designs allow one, several, or all of the group to be restrained briefly for routine examinations, such as pregnancy checks and treatment.

In housing arrangements using two rows of freestalls parallel to the feeding area, it is common to have more feed barrier openings than freestalls. This allows the entire group, even with slight overstocking, to be restrained at the fenceline at one time. In housing systems using three rows of freestalls parallel to the feeding area, there are approximately 25% more freestalls than feed barrier openings. Therefore, the entire group may not be restrained at one time, which complicates animal handling during routine examinations.

Access And Observation

Proper design allows each group to be observed easily and completely. Access to each group should be convenient. A person should not have to open a gate to enter any group. Convenient access to a group also allows escape if necessary.

Pass-throughs are commonly placed at each end, and in the middle of, each fenceline along the feed

delivery alley. They are also often placed next to gates used for cow traffic. Some gate designs incorporate a pass-through within the gate. The clear opening of pass-throughs range from 10"-16" depending on the location and person(s) using them. A rule of thumb is to use a 10"-12" opening where cows may face the pass-through, and a 12"-16" clear opening where cows 'pass' the opening. Self-closing, one-way gates should be used in pass-throughs wider than 16".

Some dairy producers use decks strategically placed above groups for observation. The herdsman observes the herd for heat detection and general health from this location.

Freestall barns with fenceline feeding offer the opportunity for the herdsman or manager to drive along the feed delivery alley frequently to observe the herd.

Provide adequate access for a tractor, or skid-loader, to easily enter each group for the removal of

a downed animal. Freestall partitions should be designed for easy removal to free an entrapped cow.

Lighting

Lighting in the housing area should allow 24-hour operation and observation (Graves and Light, 1980). The minimum light available at any time should be 200 lux (20 fc) in the feeding area and 100 lux (10 fc) in the general housing area. In areas where close examination or surgery is performed, 1,000 lux (100 fc) is recommended (ASAE, 1992). Fixtures should be placed to minimize shadows and bright spots since animals tend to balk in these areas (Grandin, 1989).

Natural Ventilation

Good ventilation is essential for good animal health. Just by respiration, dairy cows produce three to five gallons of moisture per day. Good ventilation provides the air exchange necessary to remove this moisture, as well as other moisture, gases, heat and dust in the housing area. In most climates, natural

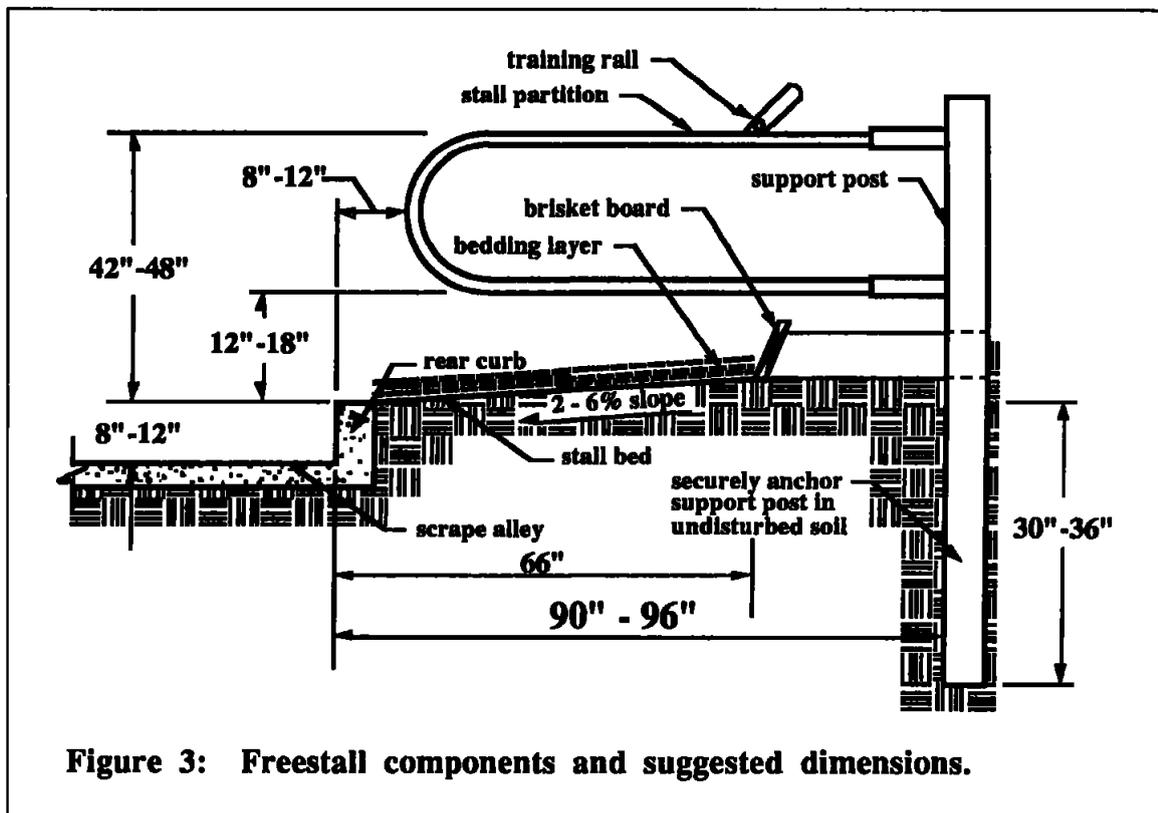


Figure 3: Freestall components and suggested dimensions.

ventilation is the most practical system for freestall housing.

Dairy housing structures should provide shade in the summer and block winds during cooler months. Proper building orientation is important. In most cases the ridge should be oriented perpendicular to prevailing winds. This allows summer breezes to blow across the width of the building when the sidewalls are open, and the ridge opening to 'draw' air more uniformly year-round.

Open-front buildings, especially those with a monoslope roof, should be oriented to provide shading during the afternoon in the afternoon. The building should be located a minimum of 50' from obstructions which might block air flow. The 'wind shadow' created by tall and/or long obstructions may increase the necessary separation distance.

Sidewalls should be 12'-14' high. This height increases the volume of air within the housing area which can improve air quality. The intensity of heat radiation from the roof material is also minimized improving hot weather comfort. The sidewall should be open a minimum of 50%. However, 75%-100% is preferred. When the sidewall is fully open, fresh air should be introduced at the cow's nose level when she is resting in the stalls.

A continuous ridge opening is recommended. Typically, 2"-3" ridge width should be provided for every 10' of building width. An open ridge is preferred, but gutters and ridge caps are sometimes used to reduce the amount of rain and snow which enters the building. Generally, a ridge cap design is acceptable if it does not restrict the opening.

Freestall (resting) Area

Properly designed freestalls provide a clean, dry, comfortable resting area with good air circulation, protection from other animals, and do not cause injury or trap a cow. Ease of maintenance is also important, but animal comfort and cleanliness should be the primary concerns when selecting a freestall combination.

The dimensions of the freestall should be allow adequate space to enter and exit the stall easily, and rest comfortably. A cow rising in a natural way, such as in pasture, lunges forward, shifting her weight forward allowing her hindquarters to be raised more easily. Observations indicate that cows prefer to lunge forward, rather than to the side, given the opportunity. Cows can exit a freestall successfully and without injury, when lunging to the side, but seem more tentative and careful about their movements.

Recommended freestall length for Holsteins is 7'6" for stalls with open fronts, and 8'0" for stalls with solid or slatted front barriers. For Holsteins (up to 1,600 lbs.) stall width of 4'0" is adequate for animal comfort and minimum chance of injury while the cow is entering, resting in, and exiting the stall.

Stall partition height and design are also very important for cow positioning and prevention of injury. In stalls of

animal size	length		width ¹	partition height ²
	A	B		
300-400 lbs	46"-52"	36"	27"	28"-32"
400-600 lbs	60"-66"	46"	32"	34"-36"
600-800 lbs	66"-72"	50"	36"	36"-38"
800-1,000 lbs	72"-78"	54"	39"	38"-40"
1,000-1,100 lbs	78"-84"	58"	42"	40"-42"
1,100-1,300 lbs	84"-90"	64"	46"	42"-44"
1,300-1,600 lbs	90"-96"	66"	48"	42"-48"

A – stall length from alley side of rear curb to stall side of partition support.
(use upper side of range as minimum when stall front is not open.)
B – brisket board and/or training rail location from alley side of rear curb.
1: – stall width measured from center of one partition to center of next partition.
2: – partition height measured from top of rear curb to top of partition.

proper length, a brisket board and adequate stall base slope help position a the cow in the stall and keep the back of the stall cleaner.

The stall bed should provide good 'cushion' for the occupant. Cushion might be defined as a surface which gives slightly to cradle the bony protrusions of a resting cow, distributing her weight more evenly across the stall bed. A comfortable stall bed will encourage the cows to use the stalls rather than the alleyways.

There are several stall bed alternatives which give adequate cushion. A earth stall bed with a generous bedding layer, and a clean sand stall bed are excellent choices, but should be maintained regularly to encourage cow acceptance, cleanliness, and prevent injuries. Embedding tires into earth or concrete makes a very stable stall base. The tire sections provide a degree of cushion, however, a generous bedding layer is still required.

Many producers have adopted fabric-covered freestall beds in their systems. This option requires less bedding since most of the bedding layer is contained beneath a layer fabric.

After a firmly tamped base is established, a generous layer of bedding is added to the stall base. Next, a layer of heavy fabric, such as woven polyester, is placed over the bedding layer and fastened to the brisket board. With organic bedding such as sawdust, straw, shavings, hay and peanut hulls, the fabric may be draped over the rear curb. This allows easier access to the contained bedding layer to remove wet spots, level the bedding, or add additional material. A light layer of bedding on top of the fabric is still required to absorb ma-

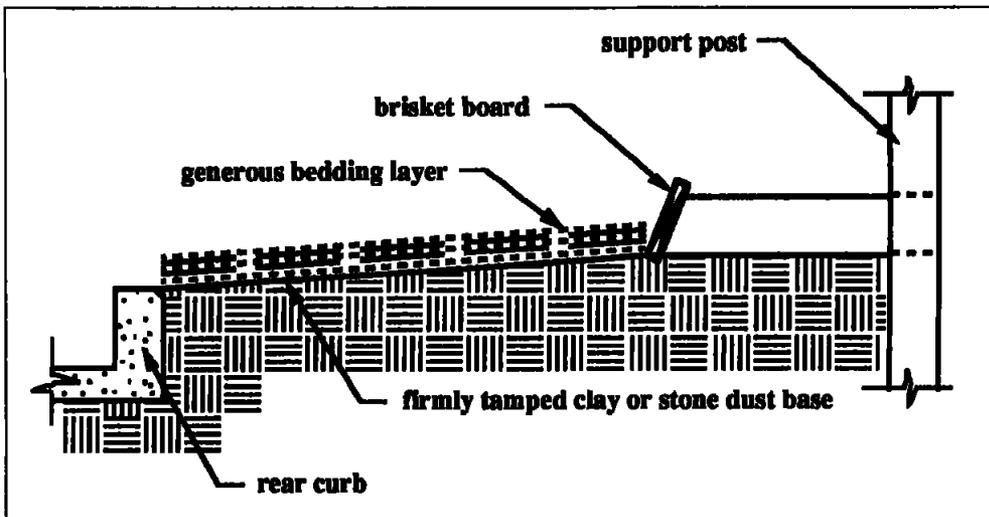


Figure 4: Earth freestall bed.

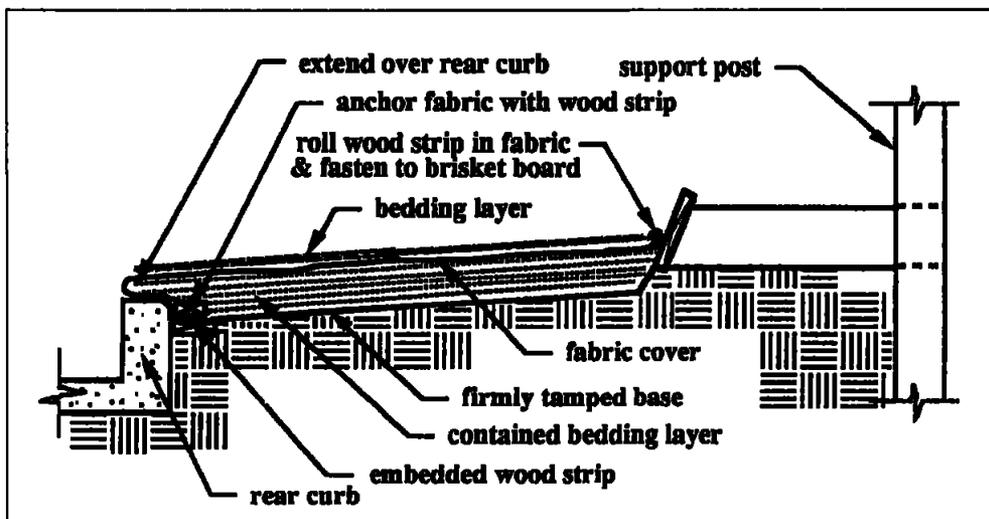


Figure 5: Fabric-covered freestall bed (fastened at rear).

nure and moisture tracked in from the alleys.

More recently, shredded or chopped rubber has become a popular choice as the contained bedding layer in fabric-covered stall beds. The rubber material is resilient and provides excellent cushion if installed properly. Observation indicates that 250-300 lbs. of shredded rubber is required per stall. The fabric is typically fastened at both the front and the rear of the stall to prevent the material from getting into the manure system.

'Freestall' does not mean 'free of maintenance'. The stalls need to be maintained regularly to insure cow cleanliness and acceptance. Manure and wet spots should be removed one or more times per day. The stall bed should be filled and leveled as required. Cows are reluctant to use, and may become trapped in, stall beds which are hollowed out or slope toward the front of the stall.

Feeding Traffic And Delivery

One of the most important materials handling tasks on the farm is the mixing and delivery of the feed ration. The design of the feeding system should provide the following:

- 1). Simple, convenient delivery of the feed to each group.
- 2). An area which encourages, and allows, each cow the opportunity to consume the proper amount of the ration.
- 3). Easy removal of old feed and debris from the bunk or feed manger.

General Layout And Considerations

Fenceline feeding with a mobile mixer/feeder allows flexibility in the location of feed storage and delivery location. Several rations may be mixed and delivered to different groups, buildings and/or other farms using the same equipment. If only a one-feed mixing and delivery vehicle is used, a trailer-mounted model is preferred over a truck-mounted model since an alternative power unit (tractor) may be connected if the regular unit is down.

Forage storage should have convenient access from fields. Supplement and/or commodity storage(s) should have convenient access from the highway. (Brugger, 1990).

Brugger (1990) suggests that the layout of the storage, mixing and feeding areas should be designed around a good traffic pattern. All sites, and the roads between, should be well drained and able to support daily traffic year-round and in all types of weather. The feed delivery unit should move forward with a minimum of backing. Adequate space and reference markers should be provided when the delivery unit must be backed into place.

Wherever animal traffic lanes cross the feed delivery units regular path, cattle guards and automatic gate and door openers allow the feeding unit to pass through without requiring the operator to leave the controls.

The width of feed delivery alleys range in width from 6'-20'. The size and type of equipment used is typically the determining factor. The mobile feed delivery unit should be able to pass through the feeding area without running over feed on the opposite side or endangering animals feeding at the fence-line.

The recommended feed delivery alley width for a drive-through freestall arrangement is 18'-20'. Each feed manger requires 30"-36" for feed delivery. This leaves 12'-15' for vehicle traffic.

The doors to the feed delivery area should provide a clear opening from manger wall to manger wall. This allows easier maneuvering of the feed delivery unit. Also, old feed may be mechanically pushed or swept from the building more easily.

The height of the feed delivery alley doorway should allow the tallest piece of feeding equipment to enter. Door heights of 10'-14' are commonly found. The recommended height is 14' or more.

For drive-by feeding, typically used with open front building layouts, the feed delivery alley may be narrower. However, the mobile feeding unit should run on a well drained, durable all-weather surface.

Feeding Space

The amount of feeding space allowed varies with the type of ration delivered, amount of time the group spends away from the feeding area, frequency of feeding, and personal preference of the dairy pro-

ducer.

If the entire group is to be fed at once, 28"-30" of feeding space should be provided for each cow in the group (Bickert, 1990). A freestall housing arrangement using two rows of freestalls parallel to the feed manger and properly sized cross over lanes can provide feeding space within this range.

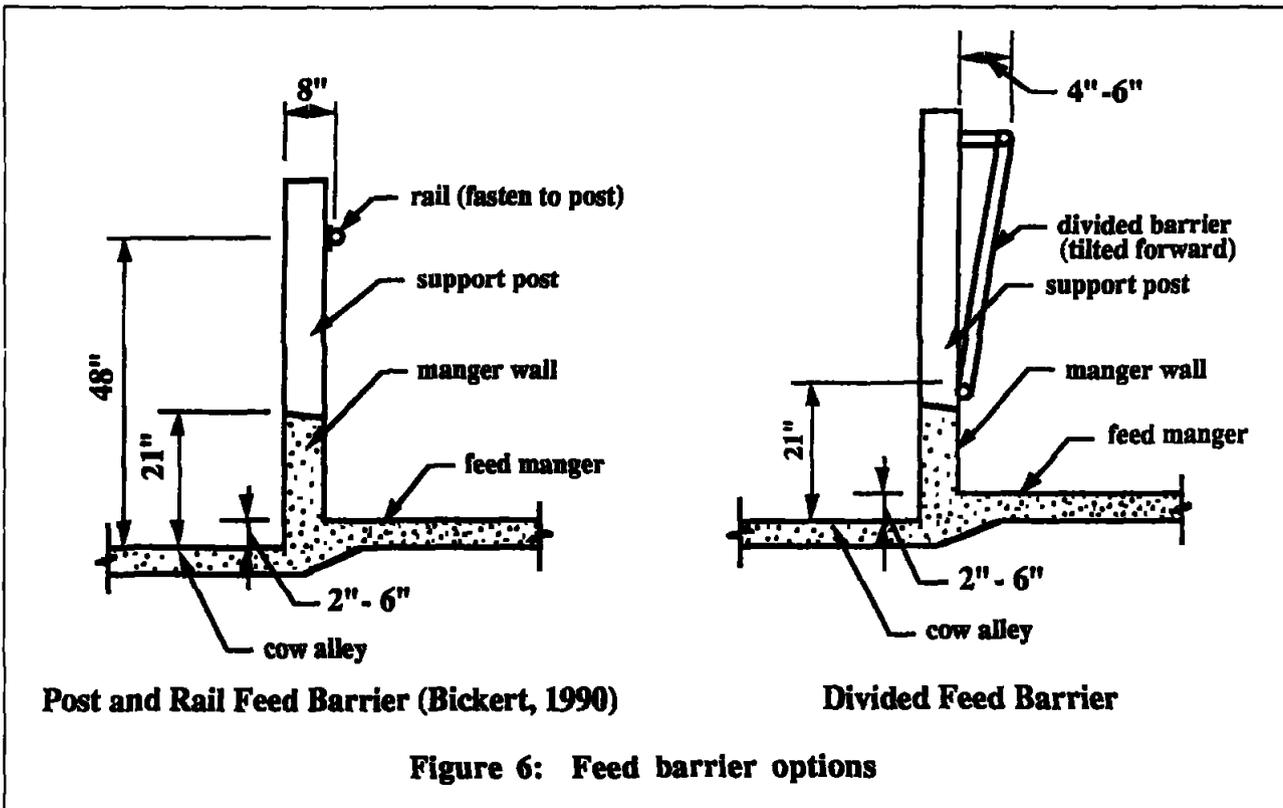
The longer that cows are kept away from the feeding area, or that feed is not available to them, it becomes more important to provide enough feeding space to accommodate the entire group at once. If forages are fed and then top-dressed, space should be provided to give the entire group the opportunity to consume the ration. Some producers who have switched from two to three milkings per day have noticed that more of the group uses the feeding area at the same time. This seems especially true when group size exceeds the number of cows which can be milked in one hour.

If a total mixed ration is fed and readily available

to the group, 18"-24" feeding space is adequate (Speicher et al., 1982). However, Bickert (1990) points out that as barns are designed and built to milk cows in the future and higher milk yields are anticipated that stress animals further, the advisability of reduced feeding space must be reexamined.

The Feed Manger

Eating surfaces must be smooth, clean and free from left over feed and other debris in order to encourage good feed intake and aid in the control of disease (Bickert, 1990). The low pH of silage can etch the manger surface, exposing the cow's tongue and mouth to rough edges (Albright, 1983). High-strength concrete and admixtures are often used to improve the durability of feeding surfaces where silages are fed. A 24"-30" ribbon of tile along the length of the feed manger will provide a durable, smooth surface if installed properly. Epoxy type coatings may also provide adequate resistance, but must be applied properly to allow good adhesion.



A manger height which allows cows to eat in a natural grazing like position is preferred. Feed tossing is also reduced in fenceline feeding with manger elevations at or near floor level, compared to deep bunks (Albright, 1983). Manger surfaces elevated 2"-6" above the cow alley work well. Minimizing this elevation maximizes the manger wall which the ration can be piled against. The recommended throat height for the manger wall, measured from the cow alley, is 21" (Bickert, 1990).

A flat feed manger surface on the same level as the feed delivery alley is preferred. This allows the manger to be easily cleaned mechanically or by hand. It also allows the opportunity for good air circulation in the feeding area. The feed manger should slope slightly away from the fenceline, approximately 1/8" per foot to help drain away unwanted moisture.

Feed will be pushed out of reach by the cows and must be swept-pushed back regularly. This can be done by hand or mechanically. Several dairy producers have recognized this task as necessary and useful in the observation of the cow groups.

The Feed Barrier

The feed barrier is a divider which separates the animal area from the feed manger. The feed barrier should provide convenient access to feed, yet confine cows to their group. It can also reduce feed waste.

The post and rail barrier is typically made of metal or wood vertical posts which support a horizontal neck rail. The neck rail may be made from pipe, cable or plank. This alternative is inexpensive and allows excellent access to feed. A typical installation of a post and rail feed barrier is shown in Figure 6. In cases where competition for feed is a concern, such as with limited top-dressed feeding, a feed barrier which divides the animals may be preferred (Bickert, 1990).

Tilting the top of a divided barrier forward 4"-6" helps reduce pressure on the shoulders of a feeding cow. It also allows her to reach further for feed. A stanchion design which allows the neck opening to be opened wider at the bottom to quickly release a

downed cow is preferred.

Water Stations

The availability of a continuous supply of clean, fresh water is essential for lactating cows. More research is needed to determine the location and type of waterers which should be used. In the meantime, make drinking water plentiful and convenient throughout the housing area, especially during hot weather.

The minimum design guidelines are to provide one waterer location or 2' of tank perimeter for every 15-20 cows in a group (Bickert, 1990). Just as important, the waterers should be conveniently located to allow cows easy access. A water station should be located in each crossover area between the feeding and resting area. Many producers have also found their cows frequently use water stations located along side traffic lanes as they return from the milking center.

Each waterer should be easy to clean and cleaned regularly. Tilting water tanks allow easy cleaning of the tank and the flush of discarded water can be used to clean cross over areas. Water tanks and vats should have drain plugs near the bottom to allow complete removal of water and debris.

Manure Collection And Transfer

The least favorite task on most dairy enterprises is often the collection, removal and distribution of animal waste. Regular and efficient removal of waste from the housing area is essential to provide more sanitary conditions and cleaner cows. With proper planning and design, manure removal can be simplified to allow effective cleaning with a minimum amount of labor.

General Layout And Considerations

To facilitate cleaning, cow alleys should be straight with no turns or dead ends. Moving manure around corners is difficult, time consuming and frustrating. Each side of the cow alleys should have a curb to contain manure and urine within the alley during collection, allowing more efficient waste removal. These curbs should extend to the collection opening. The rear curb of the freestall rows

should be high enough to prevent manure from overflowing into the stalls during removal. At crossover lanes, curb height should not be more than 8". The crossover lane should be crowned slightly to drain moisture into the cow alleys.

Cow alleys should be level across the width. An uneven alley floor results in incomplete cleaning and allows liquid to puddle.

A manure collection opening should be located at the one end of each cow alley. The alley should slope at least 1%, but not exceed 5%, toward the collection opening to give liquids the opportunity to drain. The collection gutter or pit should be at least large enough to accept the amount manure from all of the alleys it services. Tractor-scraped alleys require more collection capacity than mechanically scraped alleys, since the alleys are typically scraped less frequently and more rapidly.

The collection opening should be at least 12" and span the entire width of the alley. The opening should be covered or guarded from animal and people traffic. The opening should not interfere with cow, or vehicle, traffic. Grates are often used to cover collection openings to allow manure to pass through and cow traffic cross. However, a grate with an acceptable opening for cows traffic, say 1", does not allow manure to pass through easily.

A good location for the collection opening is just outside the traffic lane fence. The opening can be fenced to prevent accidental entry, yet remain open to allow manure to be scraped to it without lifting a cover or opening a gate. If the building arrangement allows manure collection between groups a section of the building, say 2' in length and the width of the building, can be dedicated to the collection of scraped manure. This area can also cover a gravity-flow gutter to transfer waste from the building.

Collection methods:

The most common methods of removing manure from the cow alleys of freestall barns are tractor scraping, mechanical scraping, flushing, and slatted flooring.

One common method of cleaning alleys in freestall housing is with a tractor-mounted scraper blade

or skid-steer and bucket. This can be a very economical and flexible alternative since one piece of equipment can be used in several locations, and also be used for other tasks. The preferred time for alley cleaning is when the cow group is away from the area to reduce stress, excitement and chance of injury.

Metal scraper blades can smooth floor surfaces, making them slippery and hazardous for cows to walk on. For several years, large quartered tires (split lengthwise, then in half) have been used as a scraper blade alternative. 'Tire scrapers' do not wear the floor surface smooth and do an excellent job of cleaning.

Mechanical scrapers are pulled by a chain or cable. They move slowly in the alley allowing cows to step over them when they pass. Mechanical scrapers can be controlled to automatically cycle several times per day, or run continuously if desired. The main advantage is that the alleys can be cleaned frequently with cows in the housing area and without human labor. However, hand cleaning is still required at cross alleys and at the end of the alley where the scraper blade cannot reach.

Slatted flooring has gained popularity with some dairy producers. Openings in the floor allow manure and urine to pass to a collection gutter or storage below. Manure is worked through the openings by the feet of the cows during normal traffic. The result is, typically, alleys that are very clean and dry which may contribute to good foot and leg health.

There does not seem to be a consensus among dairy producers, animal scientists, veterinarians, builders, or agricultural engineers on the use of slatted flooring in lactating cow housing. It seems that this too is a topic that needs more controlled study. Some of the pros and cons seen by those who like and dislike slatted flooring are listed below:

Advantages of slatted flooring:

- 1). Provides excellent dry floor surface for cows.
- 2). Don't need to enter cow group to clean alleys.
- 3). Non-mechanical manure collection.
- 4). Cows tend to stay cleaner, even if they lay in alleys.

- 5). Less manure tracked into freestalls.
- 6). Manure storage under building (saves space and out of sight).

Disadvantages of slatted flooring:

- 1). Cows hesitant to walk on slatted flooring.
- 2). Manure builds up on slats making them hard for cows to walk on.
- 3). Manure storage under building (gases and odors).
- 4). Cows may injure their feet and legs in the openings (although few users complain of this).
- 5). Expensive.

'Conventional' slats use a 1.75"-2" opening between treads approximately 6"-8" wide. The opening spans the width of the cow alley. A design becoming popular in some areas is the 'waffle' slat. This design uses a series of openings approximately 1.75"x8" spaced about 3" lengthwise and 5"-6" apart. In use, cows seem to walk very comfortably on this flooring surface and manure passes through quite easily.

The best advice to give producers considering slatted flooring is to go see several installations where it has been used by dairy cows for a few years or more. The combination of the owner and manager comments, and personal observations should be helpful in making a final decision.

Flush systems have been used in warm climates to clean alleys for many years. They have become more popular with new dairy systems in the Northeast and Upper Midwest. Properly designed and managed, a flush system can provide efficient and complete cleaning of the cow alleys. Flushing will not wear the floor surface and cleaning may be done while the cows are in the housing area. If temperatures are too cold to flush the alleys, they can be cleaned with a tractor and scraper easily since there are no obstructions in the alleys.

Flush cleaning is a system that needs to be designed and managed properly. It uses a tremendous amount of water, even if it is recycled. A flush system includes flush tanks or valves, a collection pit, a separator, settling basins, water storage tanks,

pumps, and an irrigation system. Careful thought should be given to how both the solid and liquid portion of the waste will be managed.

Alley Cleaning Frequency

The cleanliness of cows is directly related to the frequency which the alleys are cleaned. Producers have noticed a considerable increase in cow cleanliness when scraping frequency was increased from two times per day (approximately 12 hrs. apart) to three times per day (approximately 8 hrs. apart). Mechanical scrapers can be operated continuously or programmed to scrape at selected intervals throughout the day. More frequent scraping allows less manure to collect in the alleys and can provide a better environment for cow cleanliness and foot health.

Hand cleaning of some areas is difficult to avoid. Cross alleys, freestalls, and areas out of reach of the scraper must be cleaned regularly. The secret is to make this task simple and convenient so that it will get done. Place the necessary tools, such as scrapers and brooms, near the required areas. They should be out of reach of the animals and not interfere with animal or feeding traffic.

Summary

Housing designs that keep cow comfort in mind provide the opportunity for good feed intake, milk production and herd health. Proper planning can also make the tasks of feeding, animal handling, milking and waste collection more convenient. When the housing design combines animal comfort and effective use of labor, more time can be spent on management of the dairy enterprise – which often leads to improved profitability.

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notes

Dairying In The Future:

**Some questions you may want
to ask about past experiences
and coming challenges.**

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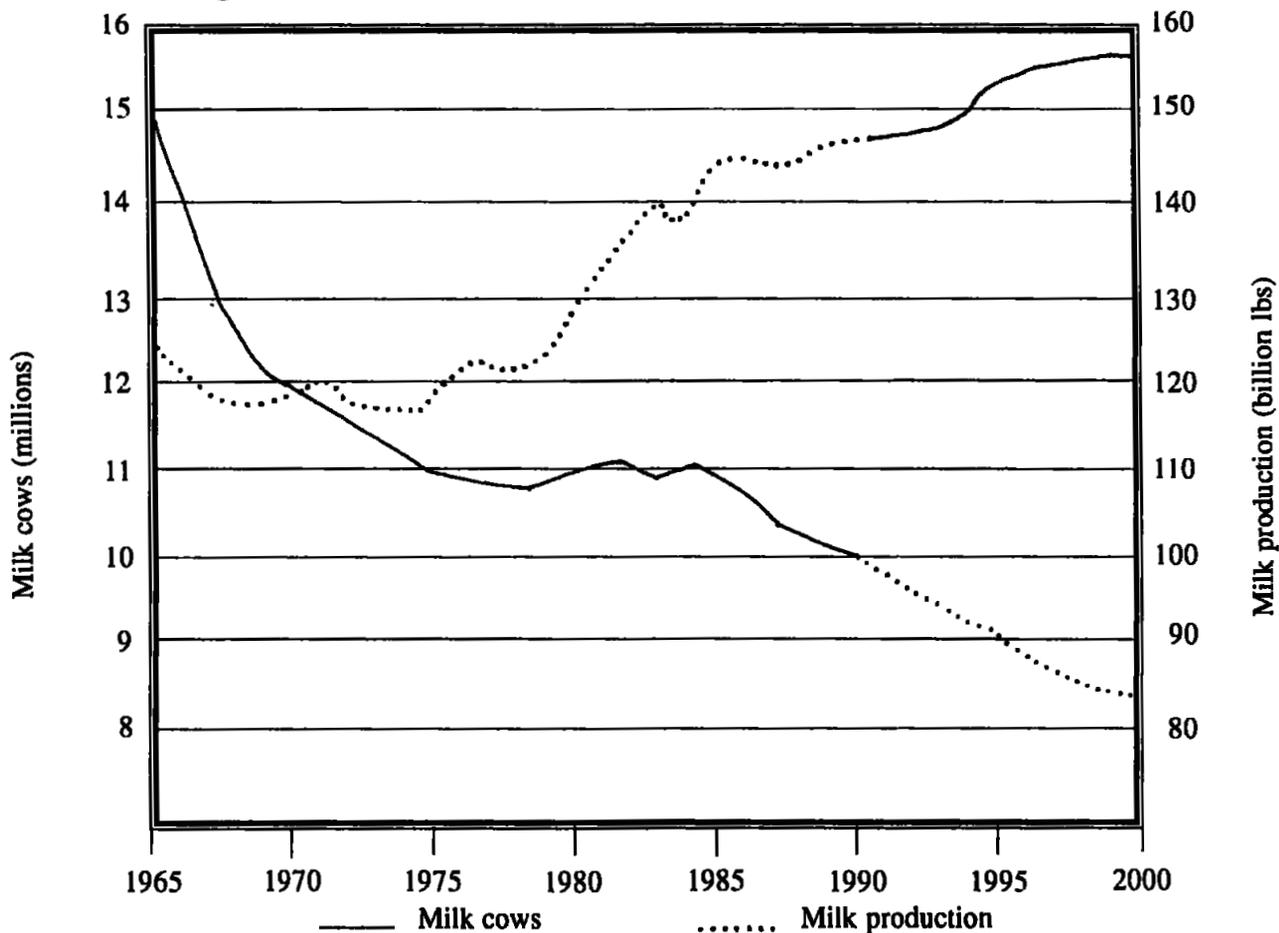
One could design an entire conference around the subject of what dairymen will need to know to dairy in the 21st century and beyond. Most of the answers can be found in reviewing the past. I have chosen to zero in on just a few areas I think will be important for dairymen to consider as our industry progresses into the next century. Let's not dwell too much on where we are today, because dairymen who are not on the cutting edge and using the tools available to them probably will not be around to be competitive in the years to come. Ours is a shrinking industry when it comes to numbers of people involved, yet truly a growth industry when it comes to production per cow, output per man hour and rapid technological

advances.

The overall size of the dairy sector is dependent upon sales, and sales are determined by the changing demands and desires of consumers and their willingness to spend hard dollars on what they perceive to be the healthfulness of the foods they eat.

Change will continue to be the common denominator in the dairy industry. In the mid-1940s, 5 million farms reported milk cows. By 1959 well under 2 million farms reported milk cows. Reductions in farms with dairy cows dropped even more percentage wise during the 1960s, when dairy operations terminated on more than 1.2 million farms, a 10-year decrease of 68%. This trend has persisted in the 1970s and 1980s. The 1987 census reported

Average Number of Milk Cows on Farms and Total Milk Production, 1965-2000



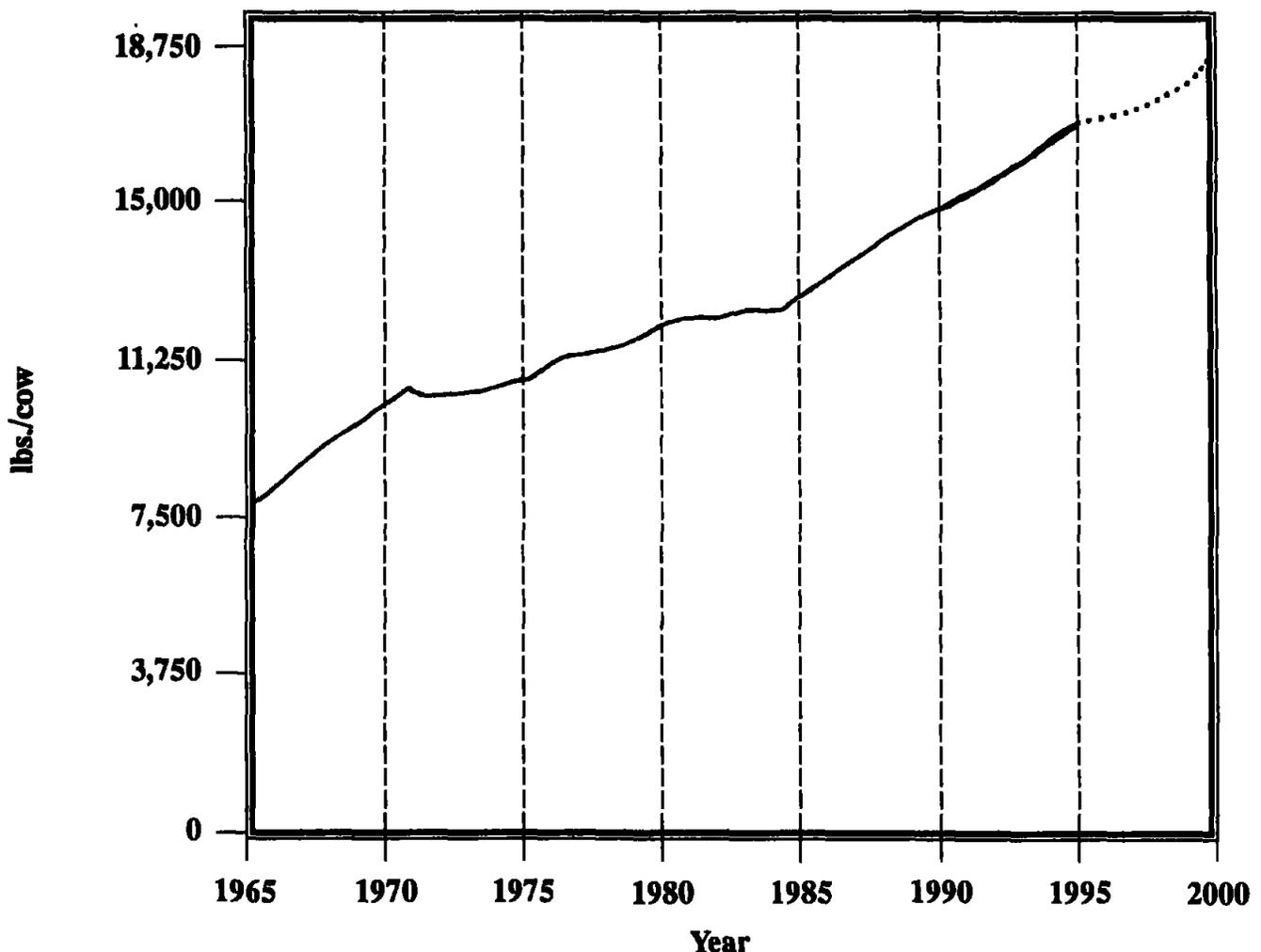
202,000 farms with milk cows. In 1987, two-thirds or 138,000 dairy farms, accounted for over 90% of all milk cows in the U.S. This reduction in dairy farms has been accompanied by rapid declines in the size of the nation's dairy herd. During the 1940s and early '50s, milk cow numbers were nearing the 25 million number. Major decreases brought cow numbers near 11 million in the mid 1970s. By 1993, the number of milk cows dropped below 9.8 million – the smallest national herd in over 100 years.

The decrease in milk cow numbers is a result of farm productivity increasing at a faster rate than dairy product sales. A look at productivity trends

shows a steady increase in milk per cow. U.S. dairy-men have realized a 300% increase in average milk production since 1940, from 4,600 lbs. per cow to about 15,500 lbs. per cow in 1993. Since 1960 the rate of gain has been about 275 lbs. per year. I look for this trend to accelerate substantially.

Census data shows the average herd size going from 5 cows in the 1940s to just over 50 cows in 1987. Data for 1993 indicates that there were 9.7 million cows on 175,000 farms. Production per cow average 15,554 lbs. and commercial disappearance of products was 150 billion lbs. of milk. Assuming milk production only keeps up with population

Annual Milk Output Per Cow, 1965-2000



growth of about 1% per year and production per cow grows at its historic rate of about 2% per year, then cow numbers must decline over 10% by the year 2000. If farm size moved up from 55 cows to an average of 75 cows per dairy, the number of dairies in the U.S. would decline about 35%. One can surmise from the above if new technology increased production to 3% from the historic 2%, then cow numbers would decrease by almost 19%

by the year 2000, all

else being equal. If we assume technology advances results in more larger farms and greater productivity gains to the point that the average herd size rises to 100 cows instead of 75, then farm numbers will decline 51% over the next 10 years.

By the year 2000, there will be 8.5 million cows in the U.S. on about 90,000 dairies, with production of about 18,500 lbs. of milk per cow totalling 157 billion lbs. of milk. The greatest production increase will be in the West. New York and Pennsylvania will show moderate growth and by the late

Top 5 States - Production / Cow		
California	19,425	
Washington	19,377	
New Mexico	19,272	18,930
Arizona	18,402	
Colorado	18,175	
U.S. Average	15,554	
Bottom 5 States - Production / Cow		
Arkansas	12,206	
West Virginia	12,043	
Kentucky	11,844	11,585
Louisiana	11,835	
Tennessee	11,492	

Impact of Milk Production on costs and returns*

Milk Level	Per cwt milk			Total Cost	Return to labor, mgmt. and risk
	Feed Cost	Labor Cost	Operating Cost		
18,000	\$5.76	\$0.82	\$11.60	\$2,342	\$179
19,000	5.64	0.78	11.21	2,384	257
20,000	5.52	0.74	10.86	2,426	335
21,000	5.41	0.70	10.53	2,465	415
22,000	5.33	0.67	10.26	2,511	490

* Values are based on \$12 per 100 pounds milk. Concentrate use is assumed to provide for extra production using 1 pound concentrate (\$0.08/lb) for each 2.5 pounds milk with roughage held constant.

Edward A. Fiez and Dean F. Falk

TOTAL COSTS OF MILK PRODUCTION, \$/CWT

	1987	1988	1995	AAGR 1988-1995	2000	AAGR 1988-2000
Upper Midwest	\$11.84	\$13.89	\$12.81	-1.2%	\$13.63	-0.2%
Corn Belt	12.54	13.88	12.87	-1.1	13.33	-0.3
Southeast	12.70	14.48	12.98	-1.6	13.12	-0.8
Northeast	11.99	12.92	12.58	-0.4	12.74	-0.1
Southern Plains	12.40	13.51	11.54	-2.2	11.56	-1.3
Appalachia	11.75	12.70	11.48	-1.4	11.35	-0.9
Pacific	10.42	11.17	9.78	-1.9	9.78	-1.1
United States	11.79	13.16	12.15	-1.1	12.40	-0.5

1990s production in the Upper Midwest may rebound.

One of the areas I want to look at and talk about is one we don't pay enough attention to in the dairy business: the socio-economic area. Recently, the Roper Group conducted a survey in rural areas. The questionnaire asked, "What do you need for your family to make a comfortable living, to set aside money for a college education for your children, retirement" and so on. The answers were gathered geographically with those surveyed in the Northeast responding

\$40,000, the South \$30,000, the Midwest \$30,000 and the West \$40,600.

Now if you relate these answers to dairy families and assume the average dairy producer in the U.S. produces about 1 million lbs. of milk a year; in order to have the lifestyle the survey indicates he'll feel comfortable with, one needs to net \$3 per cwt. That's not happening; nor is it likely to happen. I wanted to start with this premise and show why it will take an extremely competitive, efficient producer to meet the income goals referred to in the Roper survey.

Recently, Ed Fiez and Dean Falk, with the University of Idaho Extension Service, studied milk production costs and returns; their conclusions are significant. They found at the 18,000-lbs. milk level one can expect \$179 in return to labor, management and risk. But as milk production level increases to 20,000 lbs., or roughly 10% more, the return for labor and management didn't go up 10%... It went up 100%. As we look at the 22,000-lbs. levels, we see a tremendous increase in return for labor, management and risk. Almost three times the original return. Remembering the survey results: If the dairyman is currently shipping 1 million lbs. of milk a year and trying to net \$35,000, the only practical way for him to do it is to increase production to 22,000-lbs. or more and/or increase herd size.

Now if we look at the U.S. averages for production in Figure 4, we're only two-thirds of the way there, so we've got a lot of producers who are not on the competitive edge. Their future as dairymen and providers of income at the comfort level is in jeopardy.

In a study done a few years back, the Stanford Research Institute projected total costs of production in different geographic areas out to the year 2000. In 1987 costs varied from a high \$12.70 in the Southeast to a low of \$10.42 in the Pacific region, or a \$2.28 per cwt. spread between top and bottom. In 1988, even though the total costs rose in all areas, the variance from the average ranged from a high of +\$1.32 to a low

Figure 6. North Valley avg. - Sept. 1994	Herds Ranked By Production Levels		
	low 1/3	middle 1/3	top 1/3
cwts. milk sold/cow/mo.	13.60	16.57	19.20
net receipts/cow	\$159.29	\$189.86	\$219.97
net income/cow	-\$5.29	\$8.21	\$16.39
net income/cwt.	-39¢	+50¢	+85¢

Figure 7. Income/Cow/Mo. North Valley avg. - Sept. 1994	Herd Size			
	<250 (26)	251-600 (56)	601-1000 (22)	1000+ (13)
cwts. milk sold per cow per mo	15.01	16.35	16.74	17.25
net receipts/cow	\$168.21	\$182.66	\$187.99	\$195.44
net income/cow	-\$4.17	\$9.56	\$8.50	\$13.28
net income/cwt	-28¢	+58¢	+51¢	+77¢

Figure 8. South Valley avg. - Sept. 1994	Herds Ranked By Production Levels		
	low 1/3	middle 1/3	top 1/3
cwts. milk sold/cow/mo.	13.85	16.36	18.17
net receipts/cow	\$156.12	\$183.31	\$203.11
net income/cow	-\$2.55	\$5.05	\$13.53
net income/cwt.	-20¢	+30¢	+74¢

Figure 9. Income/Cow/Mo. South Valley avg. - Sept. 1994	Herd Size			
	100-700 (34)	701-1200 (24)	1200+ (23)	3X + 1383 (9)
cwts. milk sold per cow per mo	15.01	16.35	16.74	17.25
net receipts/cow	\$168.21	\$182.66	\$187.99	\$195.44
net income/cow	-\$4.17	\$9.56	\$8.50	\$13.28
net income/cwt	-28¢	+58¢	+51¢	+77¢

WORLD DEMOGRAPHICS

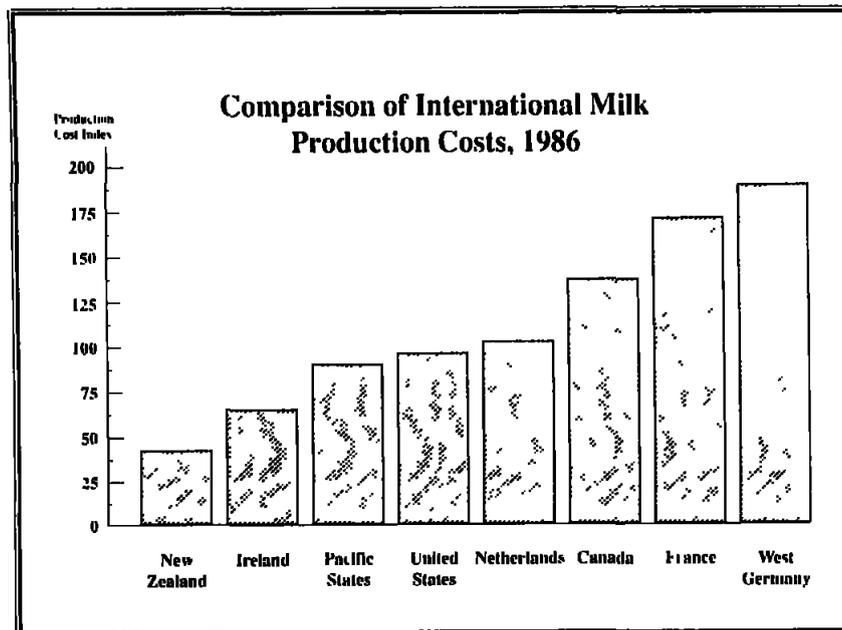
	Million/ People	% Population	% Milk Production
North America	277	5.1	20
South America	450	8.4	5.5
Europe	499	9.3	37
Asia	2,900	56.1	9.3
Japan	125	1,379	
China	1,184		
Korea	70		
Africa	795	14.9	.6
USSR*	291	5.4	23
Oceania	26	.4	3.4

of -\$1.99. When we project out to the year 2000, we see a greater total variance of \$3.85 than we saw during earlier years. In all cases the Pacific states had a tremendous advantage in costs of production. The Pacific region and the Southwest have many cost advantages in common. There is no doubt these areas will continue to grow and lead the rest of the nation by a wide margin in growth. The Northeast shows promise as a dairy area of growth and one that will be able to compete. However, the historic area for milk (or residual milk supply for the United States) is beginning to shrink. The SRI study done in 1986 predicted this would occur and the events since then have shown this to be the case. A significant "retooling" will be necessary before this region rebounds.

If we remember chart 4 showing the top five states in the country (all in the West) averaged 19,000 lbs. of milk and the bottom five states (mainly in the Southern region) with average production of 11,500 lbs., we can get a pretty good sense of who is going to be competitive and who is not. Individuals operating at these lower levels are not going to be able to stay competitive with

those on the other end of the spectrum. This becomes even more important as we become players in the world dairy markets. If we are looking at 8,000 pound differences between averages in production levels in herds that range let's say from 200-400 cows, we are looking at competitive disadvantages you cannot compensate for by cheaper costs of land, labor and other inputs.

I would like to spend some time reviewing data I analyzed from the California Department of Food and Agriculture Milk Stabilization Branch. In California about 20% of all the herds are on state-audited cost of pro-



duction studies. The herds are selected at random and about 15% of the herds are turned over annually. The cost data is collected by field auditors who actually spend time at the dairy collecting the data which is later analyzed, summarized and used in the formula for setting the state's Class 1 price. While the state personnel use these numbers in pricing, many of us use the data for many other purposes including production trends, competitiveness of our members, and so on.

Without question the single most important factor in determining profitability per herd is the level of production. The two major production areas of the state are the North Valley and the South Valley. A review of herds ranked by production level clearly shows a very strong dollar advantage in those herds with higher production. The advantage is in the form of net receipts per cow, net income per cow, and net income per hundredweight. One can argue for

FARM MILK PRICES, 1990-1992 Ranked for 1992			
Country	1990	1991	1992
New Zealand	8.04	4.64	6.07
Australia	9.83	9.26	9.25
United States	13.74	12.24	13.11
Ireland	14.43	13.45	15.33
France	15.44	14.55	15.93
Canada	18.45	19.00	17.50
Netherlands	16.35	16.36	17.60
Germany	17.20	16.38	17.61
Italy	22.68	21.71	22.06
Japan	27.91	30.14	32.06
Switzerland	33.73	32.80	33.39

U.S. DAIRY EXPORTS TO MEXICO

Product	Quantity (Tons)			
	1990	1991	1992	1993 (1)
Butter	7,066	12,011	12,029	714
Nonfat Dry Milk	3,590	19,190	24,480	31,172
Dry Whole Milk	1,278	4,258	3,636	16,308
Condensed Milk	1,392	1,041	1,878	529
Ice Cream	1,561	3,500	4,670	2,961
Casein	366	1,457	1,405	553
Cheese	1,827	3,230	5,923	3,681
Fluid Milk (2)	21,523,916	31,299,164	46,122,721	23,803,730

(1) January - June 1993

(2) Reported in liters

lower costs and other efficiencies, but level of production in general is the most important factor in profitability.

While herd size appears to give some indication of profitability it appears that once the area of diminishing returns is reached net income when measured by cow or by hundredweight is quickly erased. My guess is management loses the ability to keep the operation "fine tuned" and slippage occurs in the

area of feed efficiency and other costs.

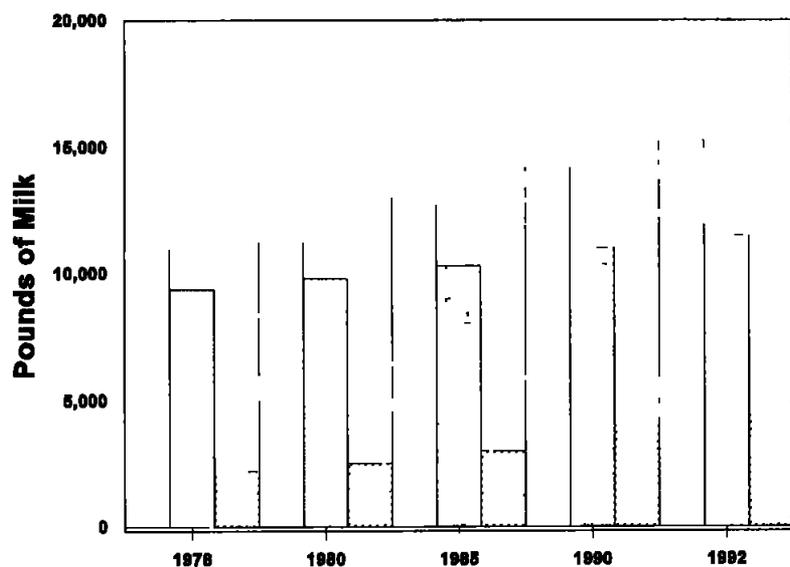
Having looked at regional costs domestically, I would like to turn our focus on world markets; after all, that's what both the NAFTA and GATT agreements were all about. Like it or not we are stepping beyond competing with each other for the U.S. market and looking at international markets. That's what DEEP, DEIP, NAFTA and GATT are all about.

Before looking at world demographics, I want to take a moment and compare U.S. dairy trends with some interesting trends in the European community. The EC-10 has had a very rigid supply management program beginning in 1985. Since 1978 when the EC-10 dairy herd numbered 25 million, it is now below 19 million – a six million cow reduction while, during the same time, the U.S. herd decreased by roughly 1 million head. The EC-10's rate of reduction was about 2.5 times the U.S. rate.

An even more interesting trend to look at is per cow production. The difference between the U.S. and the EC-10 was about 2,200 lbs. per cow, or 78% of the U.S. level. In 1992, the difference increased to 4,400 lbs. per cow. In other words, EC-10 yield had dropped to 72% of U.S. yield.

How much of loss of productivity was due to the quota system? If this trend continues won't the European Community become even more uncompetitive? Without increased subsidies or a renewed interest in regaining it's lost rate of productivity, the EC-10 may be over run with

U.S. - E.C. MILK/COW DIFFERENCE



**Projected Import Demand
Growth for Dairy Products, 1990 to 1996**

Country	1990	1996	%90-96
	(million lbs , M E)		(%)
Indonesia	485	734	+51
Malaysia	1,327	2,064	+56
Philippines	1,614	1,896	+17
Thailand	1,230	2,035	+65
S.E. Asia	5,099	7,418	+45
Japan	1,828	2,372	+30

Source: International Dairy Federation. S.E. Asia inc. Singapore

imports from less expensive products produced more efficiently elsewhere.

In one of the publications that John Naisbitt has written, *"Mega-trends 2000"*, he predicts a number of things are going to occur over the next few years. For the rest of the 1990s and into the year 2000, he predicts a booming global economy and that North America, Europe and Japan will actually form a great triangle of Free Trade. (This was written before GATT, NAFTA or DEIP.) If this is going to occur, dairying will need to become part of the big picture. He says we will soon learn to forget about the term "trade deficit" between the U.S. and Japan. His example is, can anyone tell us what the trade deficit is between Rochester and Syracuse, Seattle and San Francisco or Denver and Dallas?

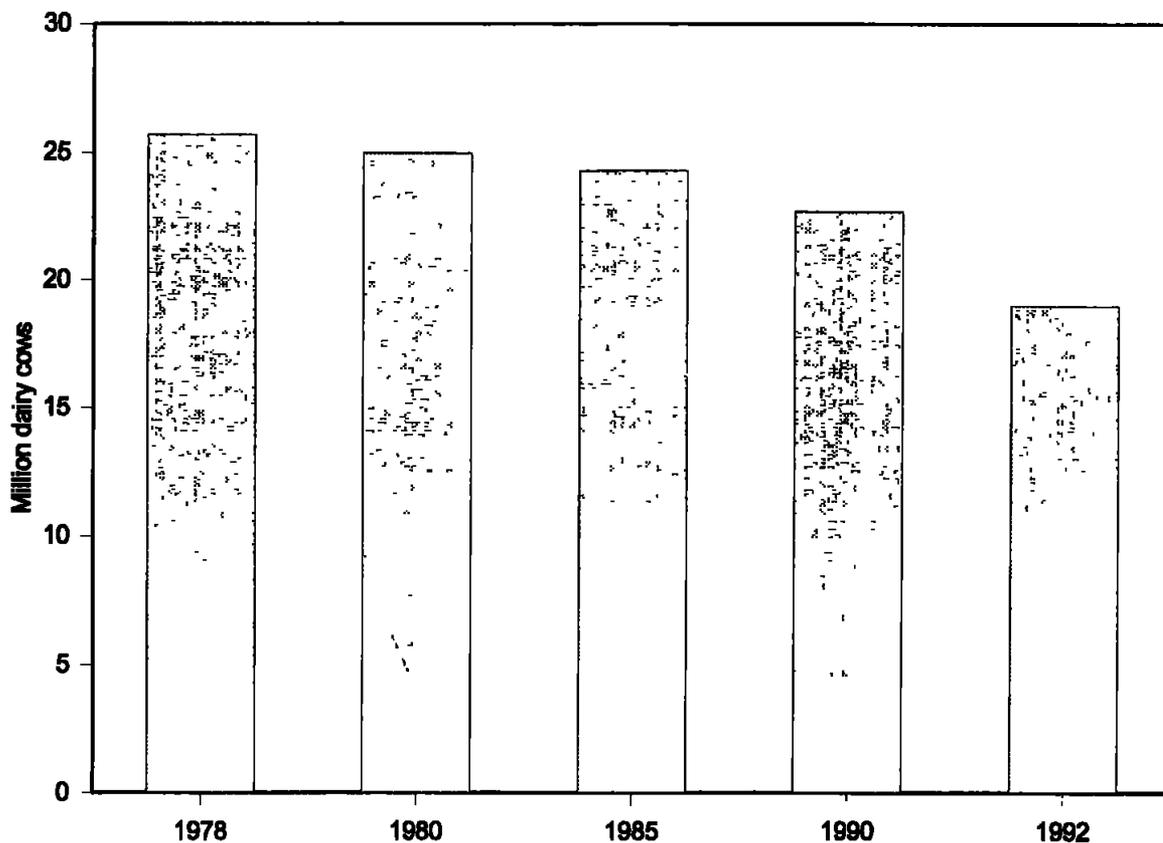
He calls for an emergence of free market socialism. Basically, protectionism as such is dying, and

it is dying very quickly. As the globe becomes smaller and smaller you learn and need to be competitive. Naisbitt talks about the rise of the Pacific Rim. Its population is more than twice that of the U.S. and Europe combined. He says Los Angeles, Sydney and Tokyo will replace New York, London and Paris as the cities of World Trade and World Importance in the years to come. He talks about the late 1990s becoming the 'Age of Biology' in the world economy. (Maybe biotechnology is more accurate.)

In looking at the numbers we can see the tremendous potential in Asia for dairy products. While that part of the world has 56% of the population, it only produces 9.3% of the world's milk.

Let's see how we stack up using cost of production numbers. Even though the data in Figure 11 is somewhat dated, I believe the relationship between

Dairy cow herd in the EC since 1978



costs is still pretty much in line. As you can see, the U.S. and especially the Pacific states can compete very well internationally. Even though New Zealand has by far the cheapest costs in the world, its total production is about equal to California's and it is questionable just how much more "cheap" production growth is available there.

If we examine our competitiveness based on farm milk prices we get an even better perspective about what our relative position is with competing nations for dairy sales. If GATT truly does moderate the level of farm subsidies, we should be nicely positioned to sell dairy products in a number of markets.

We can see some of the markets that could be real boons for our dairy producers in the near term. In fact, Mexico has been a real bright spot for U.S. dairy products since 1990. Even though the DEIP program helped make us competitive in this market, the per capita income growth in Mexico is creating a whole new generation of buyers with money to spend. Currently, per capita consumption is about one-third that of the U.S. With over 90 million con-

sumers, Mexico should remain an excellent growing market for years to come.

The National Dairy Board recently published some data showing projected demand in Southeast Asia for the 1990-1996 period. Their numbers indicated a 45% growth in dairy imports.

As these growth trends continue to develop in international markets, it becomes increasingly evident that only those producers who are committed to increasing production levels and efficiency levels will be in a position to compete for the marketplace. The marketplace as we have known it is being redefined with a new global perspective. Those producers who expect to be players in the next century will have to be innovators. Their abilities to manage will have to be keen. They must be able to adopt new technologies and adapt to changing markets. They will have to be in the upper end of the management scale. High production per cow; low costs per pound of milk produced. They will have to make things happen.

notes

Economic Decision Support Systems For Dairies

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Dairy managers need to make decisions. Some decisions affect farm and business structure and thus have long term consequences. These strategic decisions have effects over a number of years, affect the fix cost structure of the business, and are based on long term planning. Tactical decisions are intermediate in term, with consequences over a year and are made within the context set by the long term strategic plans. Day-to-day operational decisions reflect the implementation of specific production practices within the framework of the tactical plans. Information is needed to support these decision activities and must aid in the translation of strategic financial plans into specific production practices. Farm level objectives need to be translated into specific strategies within organizational areas such as production and finance. Monitoring performance and making needed adjustments in a continual process of control is an additional function of management.

Many dairies try to use production information such as DHI reports when making economic decisions, but few successfully link it with economic information. It seems obvious that decisions must be based on economics, but this is difficult because it requires integrating production performance (milk production, dry matter intake, conception rate, involuntary culling, etc.), environmental influences (seasonal climatic effects, nutrient recycling, etc.), and financial information (expenses, revenues from outputs, capital investment, etc.). Data compiled for financial reporting, including tax reporting, usually are designed for external interests, for example lenders or the Internal Revenue Service. Although this information is often the only economic information available, many times it is not immediately useful for internal operations management of the production activities on the dairy. Even if the proper data are recorded and summarized in a historically descriptive form, they are rarely processed into a predictive and prescriptive form useful to aggressive managers. Economic decision support systems for management are needed. These systems should integrate historical production records with eco-

nomical information using forecasting and optimization techniques, taking dairymen beyond production summaries toward useful economic decision-making tools.

The dairy business is composed of at least two inseparably linked components, a production entity and a financial entity. Traditionally, planning and management systems have been developed separately within these two entities with little functional (causal) connection between them. Comparative analysis commonly searches for relationships between production characteristics and financial measures, but this yields little more than correlations. However, economic models must contain causal components because managers are interested in the economic consequences of production management decisions. This functional link between production and finance is largely missing in current information systems, except for occasional sharing of database information. With the advent of microcomputers and spreadsheets many "economic" analysis tools have appeared, but most have not been scrutinized for economic validity or have ignored important factors such as interactions between production activities on dairies and variations in prices and costs. Most are formulated by animal scientists and simply assign costs and returns to a single production activity. Factors other than production affect profitability. These include constraints and opportunities created by the physical environment, prices received and prices paid, marketing arrangements, size and volume of the business, labor efficiency, cost control, capital efficiency, selection and combination of enterprises, and choice of production practices within enterprises.

Planning, Control and Models

Planning and controlling operations require information for describing past performance, monitoring on-going performance, forecasting future performance, and choosing and taking appropriate actions in a continual process of adjustment while seeking to achieve business goals. Information needs for decision support depend on the extent to which managers pursue these activities, and this informa-

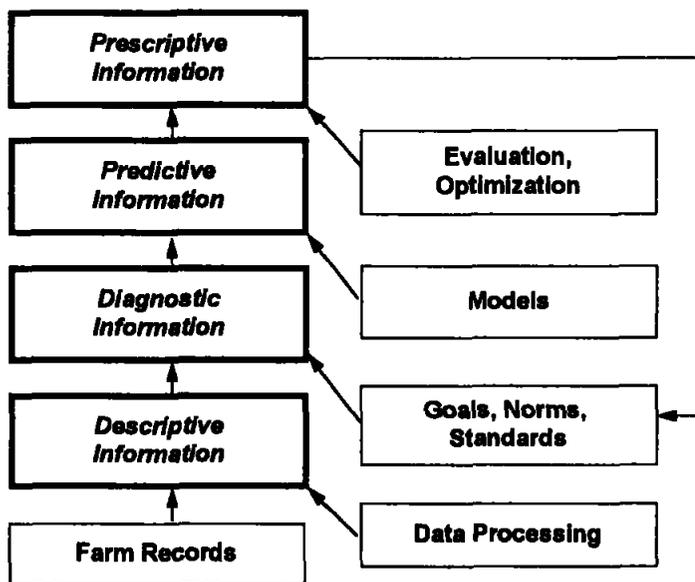


Figure 1: Different levels of Information for decision support.

tion can be organized into a hierarchy reflecting the aggressiveness of management (Figure 1). The different kinds of information are generated from the interplay of data, data processing, norms and standards, quantitative models, rules, and optimization procedures.

Descriptive information provides the foundation to generate diagnostic, predictive, and prescriptive information needed for management action. Examples include whether milk production is too low, dry matter intake is too low, feed costs are too high, net farm income or rate of return on assets are too low, or cash flow is below budget. The immediate utility of existing descriptive information systems depends on whether the data are summarized on items that are under management's control and which can be compared directly with standards important for achieving important financial goals. Thus, descriptive information coupled with norms and standards, derived externally (comparative analyses with other dairies) or internally (management goals), provide the basis for diagnostic evaluation. This type of

analysis is generally well-developed in the dairy industry and has been an important tool for dairy extension activities.

Because of the disproportionate development and use of production recording systems compared to financial information tools, management decision making has often focused on production targets and norms. Production goals are clear, concrete and relatively easily defined, measured, and assumed to be an adequate proxy for more difficult economic goals. On the contrary, economic analysis demands the simultaneous consideration of input costs, output prices, input and output quantities, plus the functional relationship between inputs and outputs. In this way, for instance, the economics of pasture based systems can be correctly analyzed.

Besides providing descriptive and diagnostic information, useful management information systems must provide predictive information for planning, and prescriptive information (advice) for improvement. Prediction and recommendations are important to determine whether and what intervention is necessary to try to alter the future. This information depends on causal, or functional models. This will be discussed later, but a complete system uses a combination of data gathering, data summarization, simulation, and optimization or searching methods to produce the information at the four levels of the hierarchy shown in Figure 1. A key feature is that the production, economic, and financial models are totally integrated.

Accounting Information

Accounting records are a foundation for economic and financial planning. Some detail is appropriate in discussing accounting because of its importance to business success and the information systems being discussed. It is also the authors' experience suitable management accounting systems can be lacking on some dairies.

Accounting aids decision makers by matching corresponding output and input quantities with their prices and costs and summarizing this information

to generate reports in formats which describe business performance. Accounting information serves three broad purposes:

- 1). It provides routine information for cost management and controlling of production operations.
- 2). It provides special, or non-routine, information to managers for strategic and tactical decisions, capital investment, and formulation of overall policies and long-range plans.
- 3). It provides information through standardized financial statements and tax returns concerning the financial position of the business to external parties such as investors (e.g., lenders), government authorities (e.g., IRS), and others for financing, investing, and other decisions.

Unlike production records, accounting information necessarily serves many masters. In different instances the type of accounting information needed and its reporting format depends on whether the decision maker is internal (e.g., manager, owner) or external (e.g., investor, creditor). This duality in users leads to two main branches of accounting: management accounting and financial accounting. Tax accounting can arguably be considered as a third. The primary objective of financial accounting is an accurate representation of a firm's economic and financial transactions, while tax accounting follows what is called the 'least and latest' rule whereby the objective is to pay the least amount of taxes at the latest possible date within the law.

External Reporting. Reports generated by the financial and tax accounting systems include tax returns and schedules, and the principal financial statements: the balance sheet, the income statement, and the statement of cash flows. To maintain sources of capital inflow it is critical for dairy producers to provide investors and creditors with accurate information so they can assess the amount, timing, and uncertainty of cash flows to them. Cash flow prospects for investors and creditors are affected by the dairy's economic resources (assets) and the claims (liabilities) on these resources (balance sheet), the dairies financial performance (income statement), the dairy's sources and uses of cash (cash flow

statement), and the dairy's overall stewardship of resources (all three financial statements).

Because financial accounting is geared to producing information for decision makers external to the business, it is critical that the information be reported in a format recognized by all potential users of the information. In the United States the principal financial statements for public firms (publicly owned = selling stock) must be prepared to conform with generally accepted accounting principles (GAAP). These rules have evolved over time or have been promulgated by official rule-making bodies such as the Financial Accounting Standards Board (FASB) as sanctioned by the Securities and Exchange Commission (SEC).

Agricultural firms generally fall outside of the domain of the FASB and the SEC. Therefore, much less uniformity exists among financial statements for firms in the agricultural sector. In some ways this can be a problem, because it makes comparing financial performance across farms more difficult for advisers and potential capital sources. To overcome this problem the Farm Financial Standards Task Force (FFSTF) was formed in 1989 and published the Financial Guidelines for Agricultural Producers in 1991 (FFSTF, 1991). The intent of the FFSTF guidelines are to bring greater standardization to financial reporting and analysis for agricultural producers and to move agricultural financial reporting into closer conformation with GAAP while maintaining aspects unique to agriculture. It is always of interest to compare performance, yet this is only possible if there is uniformity in reporting. Selection or design of a system for recording, organizing and summarizing financial accounting information should conform to the FFSTF guidelines.

Internal Reporting. Management accounting focuses on serving the first two functions of accounting information and is primarily aimed at the needs of internal decision makers. For this reason, complete standardization of management accounting systems across all dairy enterprises is probably an unrealistic and undesirable goal. Useful similarities can be expected, however.

In the dairy business the primary use of management accounting information is by managers for cost control. This type of accounting is sometimes called cost or enterprise accounting and is widely used and highly developed in most major corporations. However, it has rarely been implemented in a consistent and systematic way by dairy producers. In the dairy industry, financial accounting has generally been the sole source of financial information, and because dairy financial accounting may be relegated to outside professionals whose primary role is preparation of the tax return, financial reports can be difficult for producers to use for cost control and analysis, especially at the tactical and operational level. Financial statements are usually highly aggregated; therefore, they are ill-suited for specific analyses such as determining the cost of specific production activities.

Well developed management accounting systems can provide the needed information because they are organized around items or activities for which separate measurements are useful. Figure 2 illus-

trates this in comparison to financial accounting. Management cost information may provide routine information necessary for culling and breeding decisions for individual cows or nonroutine information necessary for making longer range strategic decisions such as whether to raise or purchase replacements, or grow or purchase feed. On dairies typical cost items can span several levels of aggregation such as the cost of the entire milking herd, cost of individual cow lactations, cost per pound dry matter, or cost per hundredweight of milk. The same accounting information can have multiple uses depending on which decisions are required.

Thus, the system must have the capability to accumulate all cost data according to 'natural' dairy business classifications, such as feed, breeding, labor, etc. It must be possible to allocate, or trace, costs to individual items or activities. For example, a load of feed may be coded for the milking herd in general, for a specific group of cows, and for a specific individual cow(s). Direct costs can be traced easily, while indirect costs can not. For example it is

relatively easy to directly trace feed costs (a direct material) and milking labor (direct labor) costs to the milking herd. However, it is difficult, if not impossible, to directly trace costs like electricity, insurance, property taxes and supervisory compensation to the milking herd, especially if the dairy consists of multiple enterprises (e.g., crop production, replacement rearing, etc.). Indirect costs, or overhead, can often be allocated using a formula.

Especially on large dairies, the proportion of total costs that are direct costs would be much higher for the milking herd than for individual

<u>Financial</u>	<u>Management</u>
Income	Income
...	...
Expenses	Expenses
Feed	Feed
Labor	Commodities
Supplies	Labor
Depreciation	Overhead
Interest	Replacements
Other	Purchased animals
	Feed
	Labor
	Overhead
	Other
	Labor
	Materials
	Overhead

Figure 2. Example of financial versus management accounting.

cows. For example, the veterinary and medicine expense for the entire milking herd would be relatively easy to directly trace. However, the true veterinary and medicine cost may be difficult to trace directly to individual cows.

Management information systems capable of providing dairy managers with reliable forecasts or profit maximizing strategies demand accurate and well-designed management accounting systems at their core. Cost control is critical. But additionally, it is difficult to choose between production alternatives without knowing the resulting costs, so costs must be known so that production decisions can be based on economic criteria.

Economics

Economic evaluation is not the same as accounting. If we assume that profitability is the primary goal of the dairy business, then economic planning, management and analysis is about managing the dairy farm resources profitably. Finance deals with the flow of funds and measures financial performance. Economics is broader and includes concepts of valuing resources as they contribute to profitability. These concepts include opportunity costs, marginal analysis, equimarginal returns, input substitution, contribution margin, and the time value of money (discounting) which are not all typically considered part of financial accounting. They are, however, important in economic analysis when determining which strategies and tactics increase profit.

Tactical and Operational Decisions. Whenever there is a way to increase profitability, it is economically rational to do so, other things being equal. This means that economic planning and management requires knowing not only what is profitable, but what is most profitable, and hence the notions of opportunity cost, equimarginal return, input substitution, etc. become important. Optimization is fundamental because economics is largely the science of choice. Business goals and limited resource availability force choice. There are normally multiple production possibilities, some more desirable than others, as measured by some criteria, and it is the essence of optimization to make the best choice.

Application of economic principles, at least theoretically, requires the revenue and cost accounting of all production possibilities, and then application of the appropriate economic principles to choose the most profitable alternative. Greatest profitability occurs when the greatest difference between total input costs and revenues is achieved, not necessarily at the lowest input costs, or most efficient ratio of inputs to outputs, although sometimes, of course, these will be the same. This is fundamentally different from simply doing an accounting exercise of costs and returns. An example (Table 1) using opportunity cost helps to illustrate the difference between accounting and economic information. The example considers the calculation of cow profitability for ranking cows for culling on economic, not production or accounting, information.

Two popular measures of dairy cow profit, total profit (similar to "lifetime") and average profit (similar to profit per day of herd life), are incorrectly applied for culling decisions, relying on untenable assumptions (van Arendonk, 1991). They are simply accounting definitions of profit, assuming that either no replacements enter the herd (total profit) or every cow is replaced by a heifer having identical characteristics as the cow leaving (average profit). The correct economic analysis considers both the future profitability of the cow and the opportunity cost of postponed replacement. Approaches which do not consider opportunity cost are not correct. The correct approach eliminates confusion caused by definitions which superficially appear to make, or reflect, common sense, but on analysis are incorrect.

Strategic Decisions, Unknowns, and Risk. It has been argued that the goal of maximum profit (implying optimization) forces simplifications of real world problems into computable representations of reality and assumes unrealistic omniscience with respect to site-specific parameter values, future product prices and input costs, and other model variables. Further, the decision maker's goal may not be equivalent to a straight forward measure of profit. A more reasonable approach, it is argued, may be to

Table 1. Differences between total profit, average profit, and real profitability.

Cow	Profit in year				TOT ¹	AVG ¹	REAL ¹
	1	2	3	4			
A	100	200	250	200	750	188	-50
B	150	250	---	---	400	200	0
C	200	300	---	---	500	250	100
D	200	250	300	250	1000	250	200

¹TOT = Total "lifetime" profit, AVG = average profit, REAL = profit accounting for opportunity cost of 200/year. Adapted from Van Arendonk (1991).

strive for constant improvement while finding satisfactory solutions for a more realistic world. Simon called this "satisficing", reasonable men making reasonable choices (Simon, 1979) in the face of complexity, numerous constraints, imperfect knowledge, unknowns, and risk.

It is true the dairy business is inherently risky due to the biological nature of milk and crop production, weather, input costs, and output prices. Decisions are also difficult because knowledge is always imperfect, information about alternatives may arrive slowly, and we often know far less than we would like about our alternatives. Actions usually create sunk costs which may be impossible to recoup and the economic environment is uncertain.

Dairy decision support methods that take advantage of optimization are most widely used for repetitive tactical decision making such as ration balancing, sire selection, and to a lesser degree culling and replacement. Although long-term strategic decisions can be analyzed using optimization techniques, for the reasons mentioned above, simulations and other forecasting methods are often found useful to determine the effects of external price changes (such as milk or feed price) and other factors effecting the success of investment decisions. Variability in potential outcomes, and thus risk, is also important to try to predict. If the risk can be described, then there are methods to incorporate it

into the decision framework.

Forecasting Revenues and Costs. Forecasts will never be perfect and the activity may be more important than the result because of what it tells the planner about the business and other forces at work, but planning is a part of control. Economic and financial planning requires predicting revenues and costs. Revenues would include at least milk yield, cull cows, number of calves sold, calf income, income from sale of assets, and investment income. Costs result from feed, replacements, labor, and other inputs. Forecasting based on last year's figures is useful if the business remains substantially the same from year to year, without improvements in management, production performance, or other factors. But with this approach there is little basis to generate predictions if the herd or management changes. Modeling the herd can be useful to predict future milk production, animal sales, and required inputs, and thus produce a detailed budget for the dairy based on:

- 1). known production performance from production records,
- 2). the current status of the dairy, including status of the dairy herd,
- 3). aggregation over all cows, and
- 4). constantly updated production data from the production recording scheme as well as the cost and price data from the managerial accounting system.

Outputs of these models can be part of the integrated planning system because they create cash flow budgets, inventories, income statements, replacement forecasts and future feed needs. Also, forecasts can be changed with different price or performance outlooks to determine business ramifications in a "what-if" framework. The future scenarios described are reported in financial terms to assess financial impacts. In a sense, this is a rigorous budgeting exercise.

Useable Information Systems

Decision support systems which include economic evaluation are beginning to appear. This paper will deal with one, but there are others which differ in numerous ways. The purpose is to illustrate the use of combining production and financial data to generate economic information in a useful format for dairy managers, not to promote one system. Simulation and optimization are used, and the overall purpose is to provide better information to dairymen as they try to make necessary decisions to control their businesses. The specific application that will be discussed is the Florida Dairy Management Project (FDMP), because the authors are most familiar with it. The information system is called the FDMP-MIS.

An overview of the production and economic data collected from each dairy is listed in Table 2. These data are dairy specific and are delivered through several methods. Although not required, all current FDMP dairies are enrolled on DHIA testing and the herd production history, current herd production, and cow reproductive records are downloaded directly from the appropriate DRPC and maintained in a database. Other data summarized by DHIA (e.g., monthly conception rates, heat detection rates, 2X 305d ME, cow mortality rates) are directly recorded/calculated from the DHI Herd Summary file. Additional data on actual milk sold per month, animal inventories, feedstuff nutrient analysis, ration composition, feed usage, etc. are provided directly by the dairy producer. Most economic data come directly from the producer and primarily consist of monthly income statements,

forecasted milk prices, feedstuff costs, replacement costs, carcass and calf prices, short-term interest rates, etc. Financial and economic data are summarized and maintained in a database.

Models. At the heart of the FDMP-MIS are two models which:

- 1). are causal because they predict production possibilities based on individual cow and herd production characteristics specific to each dairy,
- 2). integrate production and economic data specific to each dairy,
- 3). base decisions on economic criteria, and
- 4). generate predictive and prescriptive information for management decision making specific to the production and economic conditions existing, or predicted for, each dairy.

The first model is a dynamic programming (DP) model developed by DeLorenzo et al. (1992). This model finds profit maximizing insemination and culling/replacement policies. It maximizes profit from each cow position in the herd. The model integrates dairy-specific production and economic data (Table 2) to calculate the net present values for every cow. Essentially, the model makes one of three decisions for every month of a cow's life:

- 1). keep,
- 2). replace, or
- 3). if a cow is kept, and she is open, whether to breed her at her next estrus.

The decision to keep or replace considers the opportunity cost of postponed replacement because the cow is kept only if her net present value is higher than the average first-calf heifer competing for her position in the herd. The production and economic characteristics of the first-calf heifers are based on dairy-specific data on first-calf heifers calving in the month of replacement.

The second model is a simulation model which is integrated with the DP. The simulation model predicts the herd's monthly milk production, feed costs, herd structure (total herd size, number of dry and milking cows), number of culls, number of calvings, and number of pregnancies. On a routine basis (each month) two scenarios are calculated. The first

scenario is predictive and produces a forecast for the dairy under the assumption that the dairy producer will continue to follow present breeding and culling policies. The second scenario is prescriptive and produces a forecast, or goal, under the assumption that the producer is following optimal breeding and culling policies as prescribed by the DP model.

An important feature of the FDMP-MIS is the flexibility of the DP and simulation models in allowing a wide variety of possible production and economic scenarios to be examined. Dairy producers often request special scenarios examining a multitude of

possible management strategies (e.g., BST use, A.I. vs natural service breeding, etc.), alterations to farm structure (e.g., expansion, heat stress abatement structures and equipment, etc.), and changes to herd structure (e.g., timing effects of additional heifer purchases, etc.). The strategy of using dairy-specific data is essential to the success of the basic FDMP services and allows the special scenarios to provide meaningful information. It insures that the information received by a dairy manager has been tailored to the unique conditions found on his dairy. Accurate accounting data is required. The breeding and

Table 2. Production and economic data used by the Florida Dairy Management Project.

Production	Economic
Cow milk production history	Actual milk price by month
Cow current milk production level	Forecasted milk price by month
Cow current reproductive status	Milk fat differential
Herd milk production level	Milk protein differential
Milk fat %	Feed cost per lb DM (high producers)
Milk protein %	Feed cost per lb DM (low producers)
Monthly conception rates	Beef salvage price
Estrus detection rates	Replacement cost
Ration NDF concentration	Calf values
Cow body weights by parity	Discount rate
Calf body weights by sex and parity at calving	Short-term interest rate for purchased replacements
Calf mortality by parity	Feedstuff prices
Involuntary culling rate	Actual monthly revenues and expenses
Genetic progress per year	
Animal inventory	
Actual pounds milk sold per month	
Projected heifers to freshen by month for next 12 months	
Feed information:	
feedstuff nutrient content	
ration composition	
group daily intake	
cow numbers per group	
Minimum milk per day (high producers)	

culling model is particularly useful to account for complex seasonal patterns of milk price, milk production, and reproductive performance.

Once the herd's production characteristics have been generated for the next 12 calendar months this information is further integrated with expense and revenue data from dairy-specific income statements. Integration of these production and economic data allow the generation of descriptive (actual/past), predictive (forecast), and prescriptive (goal) cash flow and/or income statements for the next 12 calendar months. This final link in the process allows dairy managers to ascertain the economic consequences of following current breeding and culling policies, optimized breeding and culling policies, or any proposed management change capable of being captured by the DP and simulation models.

Subsidiary production and economic summaries and graphs are also prepared using spreadsheets and databases. These summaries and graphs may contain all levels of information (descriptive, predictive, and prescriptive) or be limited to descriptive and diagnostic information for monitoring purposes. Such items as milk production and income per

month, purchased replacements, labor costs per cwt. of milk, dry matter intake, feed cost per cwt. of milk, etc. are summarized on a monthly basis.

Management Reports. A report received by FDMP dairy managers each month are a set of breeding and culling guides. Table 3 shows a portion of an actual breeding guide and Table 4 a portion of an actual culling guide. These guides suggest, for the current month, from a profit-maximizing standpoint, which cows in their herd should receive the highest priority for breeding and those that are likely cull candidates. In the breeding guide each open cow in the herd has a value (Value Insemin.) indicating the expected net discounted return from inseminating her at her next estrus versus waiting. The relative breeding values can be viewed as a priority list for breeding. Thus, cow #3019 should receive the highest heat detection intensity. The culling guide shows the net present value of keeping a cow versus replacing her with an average first-calf heifer calving in the month of replacement. For example, it is recommended that cow #6 be culled, other things being equal, even though her expected net cash return over the next

Table 3. Sample breeding guide.

Barn Name	Lact Num	Month Milk	Cow ME/ Herd ME	305ME	LTD Milk	Repro Code	Value Insemin(\$)
3019	2	6.7	1.26	25,442	79		319
908	1	3.1	1.01	20,505	71		36
106	2	7.0	.72	14,497	48	C	0
911	1	3.0	1.11	22,477	81		0

Table 4. Sample culling guide.

Barn Name	Lact Num	Month Milk	Cow ME/ Herd ME	305ME	LTD Milk	Keep vs Cull (\$)	Net Cash (\$) 12 Mos
9579	4	2.2	1.19	24,103	118	1,564	2,227
909	1	6.3	1.14	23,172	70	532	769
6	2	5.9	.83	16,749	55	-117	371
9396	1	10.9	.93	18,761	38	-305	-29

12 months is positive, because a first-calf heifer taking her position would provide a higher net present return (\$117). These are specific reports which recommend specific herd management actions to increase farm profitability.

The second set of outputs received by FDMP dairy managers each month are a set of cash flow reports reflecting the economic consequences on the dairy businesses' cash flow of following current versus optimal breeding and culling policies. In addition, actual cash flows are summarized for monitoring purposes and a variety of subsidiary production and economic summaries and graphs are prepared. Table 5 shows a reduced schematic example listing descriptive (past), predictive (forecast), and prescriptive (goal) cash flows. The revenue and expense categories in this example are highly aggregated and summarized on a yearly basis for illustrative purposes. In reality, three cash flow reports (past, forecast, goal) are received by the dairy manager containing 12 months of information and there are up to 25 expense categories. As indicated in Table 5, following optimal breeding and culling policies for this dairy would be expected to produce a yearly cash flow over \$106,000 higher than following current policies. Various graphs are also provided to dairy managers on a monthly basis. The graphs provide varying levels of information (descriptive, predictive, prescriptive) depending on the item of interest. Dairy managers who desire to examine possible changes in other management strategies, alterations to farm structure, and/or changes to herd structure would also be provided with a full set of cash flows, summaries, and graphs in addition to those provided on a regular monthly basis.

Human Factors. The ultimate use of the information described above is dependent upon the in-

Table 5. Example results of integrating herd-specific production and economic data using causal models to produce descriptive (past), predictive (forecast), and prescriptive (goal) cash flows. Shown in reduced schematic form only.

Item	Past	Forecast	Goal
Income			
Milk	\$7,765,194	\$8,437,720	\$8,859,128
Culls	314,194	316,327	418,355
Calves	81,476	59,495	67,025
Expenses			
Feed	\$2,981,398	\$3,495,649	\$3,646,727
Labor	1,139,964	1,300,742	1,300,742
Replacements	470,543	148,800	422,400
Net	\$3,568,959	\$3,868,351	\$3,974,639

teractions between the dairy manager and the FDMP consultant. The reports are only one source of information for the overall decision process. The dialogue between the dairy manager and consultant is the most important vehicle for delivering the decision aids. Initially, some dairymen more readily accept quantitative decision tools than others, although there are some similarities across all dairy managers. One of the most important concepts that the dairy manager must understand is the dairy-specific nature of the FDMP-MIS recommendations. Once this realization occurs, the information is more meaningful than if only a "representative" farm were described.

Conclusions

Defining management problems correctly in economic terms is important. Production recording and accounting data need to be combined into economic information to correctly support management decisions. Interactions between various factors must be considered and models that incorporate interactions between the various components of the production system are important. Information and knowledge will always be incomplete and risk is a major consideration for decision makers, especially for long term strategic decisions. The use of causal models and optimization can generate alternatives,

and although not perfect, predictions can help steer decisions and provide some measure of risk. For tactical and operation decisions that are often repetitive, profit maximizing techniques are useful and can yield specific management guides suggesting specific actions, although other information must always be included as well.

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notes

Managing Conflict In Agricultural Business

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Conflict is a daily reality for everyone. Whether at home or at work, an individual's needs, goals, objectives and values constantly and invariably come into opposition to other desires held by ourselves or others. Some conflicts are relatively minor, easy to handle, or capable of being overlooked. However, others of greater magnitude require a mindful strategy for successful resolution if they are not to create constant tension or lasting enmity in ourselves our homes or farm business.

Conflicts left unresolved and festering at the expense of the business and individuals well being are an all too common occurrence in agriculture and other small business. The ability to successfully resolve conflict is probably one of the most important personal and business skills an individual can possess. In spite of this fact there are few formal opportunities in our society to learn effective conflict management. This is partly because we do not understand conflict due to its complex nature, and partly because even if we understand conflict, and have a good inner working model of what is happening with ourselves and others in a conflict situation, that is still only a small percentage of the knowledge necessary to master to manage conflict. The next step is the development and use of interpersonal communication skills that will allow us to accelerate or decelerate conflicts to resolution.

Like any other human skill, conflict resolution can be taught; like other skills, it consists of a number of important subskills, each separate yet interdependent. These skills need to be assimilated at both the cognitive and the behavioral levels (i.e., Do I under-

stand with my mind how the conflict may be resolved and do I have sufficient mastery with interpersonal skills and behaviors to affect positive change toward resolving specific conflicts?). To learn how to manage conflict, we will first build working definitions of conflict terminology and working models for thinking about and managing conflict. With these models in place, we will move to a discussion of some specific interpersonal conflict resolution skills.

Terminology

The terminology we will use in the discussion of conflict follows:

Conflict – A type of problem involving the collision or opposition of ideas, objectives / goals.

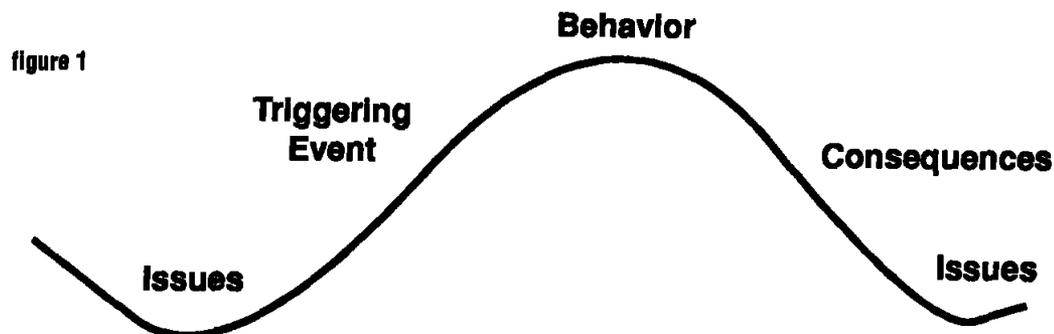
Content Conflict – A difference of opinion or clashing objectives/goals on substantive, content, formal task or procedural matters.

Interpersonal Conflict – Content disagreement plus negatively charged conflicting interpersonal relationship issues may occur in dependent, formal interpersonal relations, or independent, informal interpersonal relationships.

Conflict is not good or bad. Conflict usually holds the potential to be either, and must be carefully managed to assure the desired outcome. The following list outlines both potential outcomes of conflict.

Good Side of Conflict

- Properly managed, moderate doses of conflict can be beneficial.
- Conflict is the root of change.
- People learn and grow as a result of conflict.



- Conflict stimulates curiosity and imagination.
- Conflict helps to relieve monotony and boredom.
- Conflict can provide diagnostic information about problem areas.
- After conflict, closer unity may be re-established.

Bad Side of Conflict

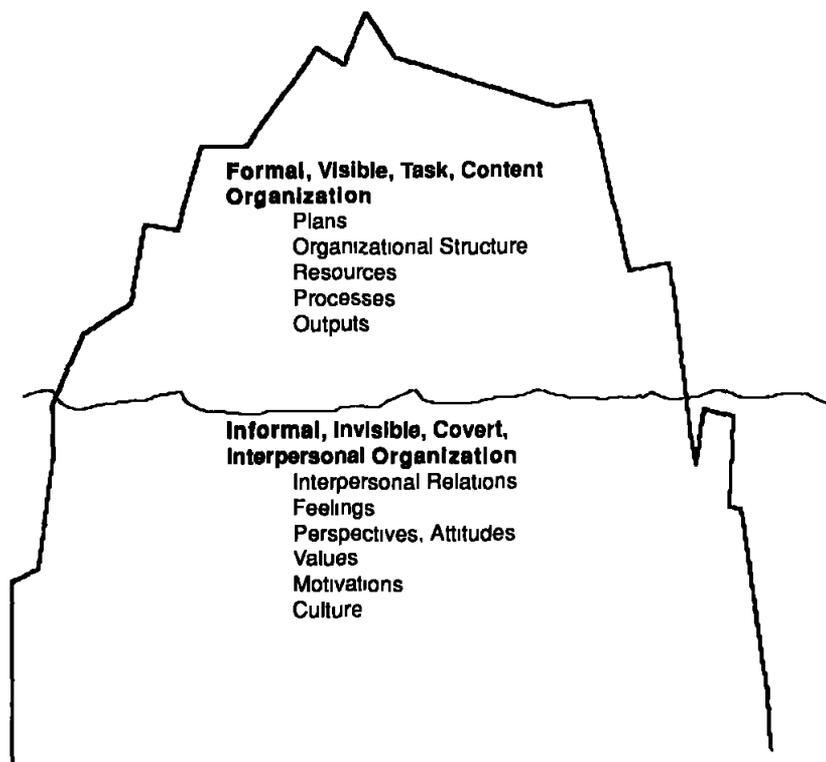
- Prolonged conflict can be injurious to your physical and mental health.
- Conflict diverts time, energy, and money away from reaching important goals.
- Conflict often results in self interest at the expense of the organization.
- Intensive conflict may result in lies and distorted information.

Conceptualizing Conflict

Conflict can result from substantive differences, that is, differences resulting from objectives, structures, policies, or practices; or it can grow out of personal or emotional differences that occur between people. Another way to examine conflict is to look at differences in four categories: facts, methods, goals and values.

These different viewpoints may exist because of differences in individuals' informational exposure (for example, reading different articles in professional journals), their perception, or the roles or positions they hold.

It can be useful to view conflict as cyclical. Overt conflict might occur only periodically when people's contrary values or goals surface through an activating event. The underlying issues may lie dormant for a while before something happens to trigger a conflict episode. Once triggered, the expressed conflict will usually become less pronounced over time, and the issues may not be apparent until the next triggering event causes the cycle to repeat itself. Richard Walton (1987) studied conflict cycles and identified four basic elements: issues, triggering events, conflict behavior and consequences.



Issues are the substantive, content or interpersonal emotional differences that underlie any conflicting relationship. The triggering event (which may be significant or very minor) causes the latent conflict to be explicitly expressed. The behavior displayed by the conflicting parties leads to the consequences of the exchange. Issues or triggering events may change from one cycle to the next, and the consequences may differ significantly. A conflict cycle may escalate, indicating that the relationship is becoming more conflicting over time. An example of this might be a deteriorating marriage in which the husband and wife begin to fight more frequently and seriously.

A conflict cycle may also de-escalate, indicating that the individuals involved are learning to adjust and work successfully, despite their differences.

In addition to events that trigger a conflict episode, there may be barriers that inhibit the open expression of conflict. For example, an individual

may be afraid of hurting the other person's feelings, or the culture of a particular organization may value teamwork and camaraderie so much that members stifle any potential conflict. If barriers exist and conflict still manifests itself, it may indicate that issues or triggering events are more significant than the barriers.

When successful confrontation and resolution is the goal of managing conflict, many underlying issues may be eliminated. Controlling conflict is another viable goal. In controlling conflict, most of the issues still exist but the negative consequences are minimized. One can control conflict by reinforcing the barriers to conflict or by preventing a triggering event from occurring. This emphasizes the importance or prior analysis of a conflict situation to determine what these elements are.

The Formal And Informal Organization

Like plants and icebergs, organizations cannot be totally seen or understood from the surface. We will briefly describe two dimensions of organizations, one above and one below the surface, to facilitate our understanding of leadership and conflict. A manager must be aware of how and be able to operate in both components of the organization for effective interpersonal conflict management to occur. Note carefully the distinction made in the model.

Context Issues Diagnosis

Diagnosing the context of a conflict is the starting point in any attempt at resolution. The most important issue which must be decided is whether the conflict is an emotional, informal, interpersonal ideological (value) conflict or a formal, content (tangible) conflict – or a combination of both. The distinction between issues of content and those of an interpersonal nature is a most useful and important one to make to then be able to rationally decide the best strategy and tactics to use in order to come to reso-

lution. The following models are useful in determining the extent to which a conflict is content and/or interpersonally comprised.

Power Diagnosis

The next issue to discuss in light of conflict is the issue of power or the lack of it. Careful diagnosis of the balance of power in a conflict will aid us in determining a resolution strategy. This discussion of the sources of power and authority is imperative if we are to understand organizational and interpersonal dynamics and be able to resolve conflicts. Power is described as influence potential: it is this resource that enables one person to gain compliance from or influence over others.

Given this integral power relationship that exists between people, managers must examine their possession and use of power in conflict situations. One can imagine that if a fight were to break out you would put your money on the largest person or the one you thought had the most power and would be most likely to win the conflict. In the case of interpersonal conflicts win/lose situations are not always appropriate and so the use of power or the equalization of power must become a management decision depending on the desired result. The sources of power reviewed in the previous exercise may come from both the formal organization and the informal sides of organizations just as conflict issues do.

These bases of power are important to understand to consciously decide to use or not use power in a given situation. The possession of power or the lack of it may profoundly affect a person's behavioral response to a conflict situation. People must be empowered if your goal is to utilize collaboration or negotiation as a means of resolution.

Balance Of Power In A Conflict

Diagnose the context of the conflict and determine who has the power in a conflict sit-

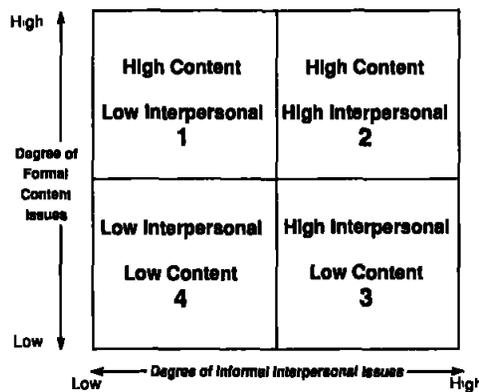


figure 3

Figure 4: Balance Of Power In A Conflict.

uation and from what source that power comes. Further, ask if the power is in balance or out of balance. This is not to say that the power should always be equalized to reach resolution. That will depend upon how you decide to handle the conflict. It may be that in a given situation you decide to increase the imbalance of power.

A. Coercive power is based on fear. A leader scoring high in coercive power is seen as inducing compliance because failure to comply will lead to punishments such as undesirable work assignments, reprimands or dismissal.

B. Connection power is based on the leader's "connections" with influential or important persons inside or outside the organization. A leader scoring high in connection power induces compliance from others because they aim at gaining the favor or avoiding the disfavor of the powerful connection.

C. Expert power is based on the leader's possession of expertise, skill, and knowledge, which, through respect, influences others. A leader scoring high in expert power is seen as possessing the expertise to facilitate the work behavior of others. This respect leads to compliance with the leader's wishes.

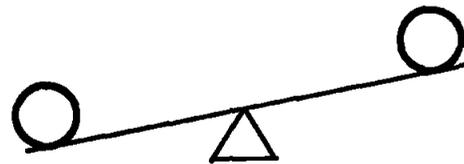
D. Information power is based on the leader's position of, or access to, information that is perceived as valuable to others. This power base influences others because they need this information or want to be let "in on things."

E. Formal power is based on the formal position held by the leader. Normally, the higher the position the higher the legitimate power tends to be. A leader scoring high in legitimate power induces compliance from or influences others because they feel that this person has the right, by virtue or position in the organization, to expect that suggestions

Power is in balance or equal between parties



Power is out of balance or unequal between parties



will be followed.

F. Personal power is based on the leader's personal traits. A leader scoring high in referent power is generally liked and admired by others because of personality. This liking for, admiration for, and identification with the leader influences others.

G. Reward power is based on the leader's ability to provide rewards for other people. They believe that their compliance will lead to gaining positive incentives such as pay, promotions or recognition.

The Technical Components:

People, Process And Context

We must look in depth at some technical issues involved in conflicts and establish some models for understanding them. All conflict situations differ. Therefore, we can never assume that all of them can be resolved in a reasonable constructive manner. Nor should we always see conflict as a life and death, win or lose struggle. Each situation should be seen on its own terms. As we look at conflict from the point of view of resolution, we will consider the following issues: the people involved, the context of the situation and the process.

PEOPLE

1. Characteristics of the parties involved

- values, motivations, aspirations, objectives
- physical, intellectual, social, emotional, spiritual development
- beliefs about conflict, conceptions of strategy and tactics

- default conflict behavior patterns integrated or polarized
2. *Prior relationships to one another*
 - attitudes, beliefs, expectations about one another
 - beliefs about other's view of oneself
 - degree of polarization (How far apart are they?)
 3. *Consequences of conflict to each participant*
 - gains and losses (wins and losses)
 - precedents set for the future
 - changes as a result of conflict

PROCESS

1. *Strategy and tactics employed by parties involved (extent of use)*
 - promises and rewards
 - threats and punishments
 - freedom of choice/coercion
 - openness of communication and sharing of information
 - avoidance
 - approach

CONTEXT

1. *Nature of issue giving rise to conflict*
 - scope, rigidity, significance frequency
 - formal – task – content
 - informal – interpersonal
2. *Social environment within which conflict occur*

- restraints, encouragements, deterrents and social norms concerning strategy and tactics
3. *Interested audiences to conflict*
 - relationships to the individuals involved

Conflict-Management Styles

(Adapted by Guy K. Hutt from Martin B. Ross 1982 Annual for Facilitators, Trainers, and Consultants)

The ability to cope successfully with conflict is among the most important social skills one can acquire. As people mature they usually develop behaviors for coping with conflict; there is even some evidence that they develop certain preferred styles (Thomas & Kilmann, 1974). Almost invariably, conflict-management skills are acquired without formal education or guidance. Usually behaviors are modeled after the behavior of others. If one is fortunate enough to have good models, and if one is lucky enough to be in situations in which the modeled style is effective, one is usually successful. If not, one may learn an effective style too late. The best way to minimize failure is to learn what styles are available, in what situations they are most effectively employed, and how to use them.

The model of conflict patterns developed for this paper, based on the earlier work of Thomas (1976), provides an excellent framework for learning various conflict-management behaviors, their situation-

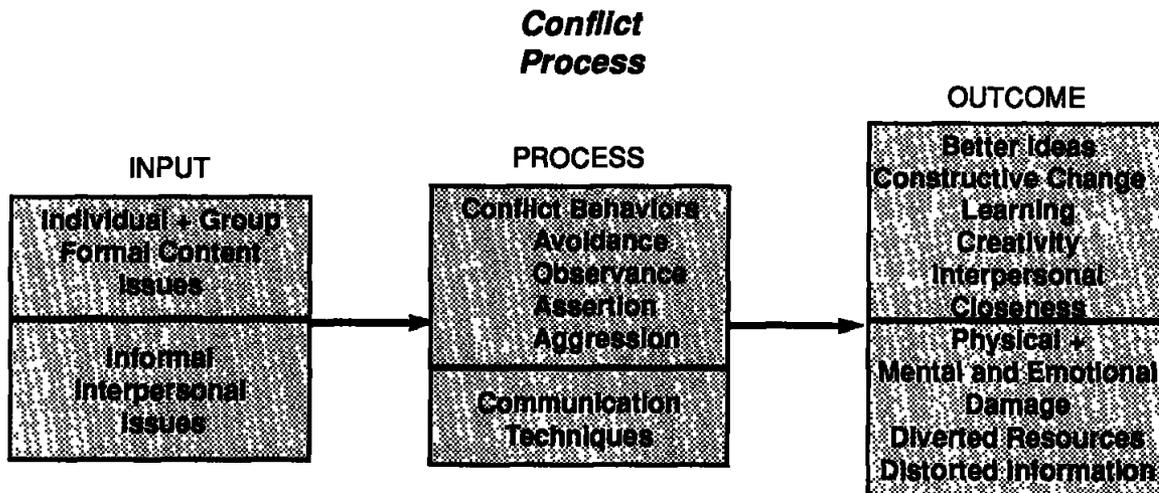
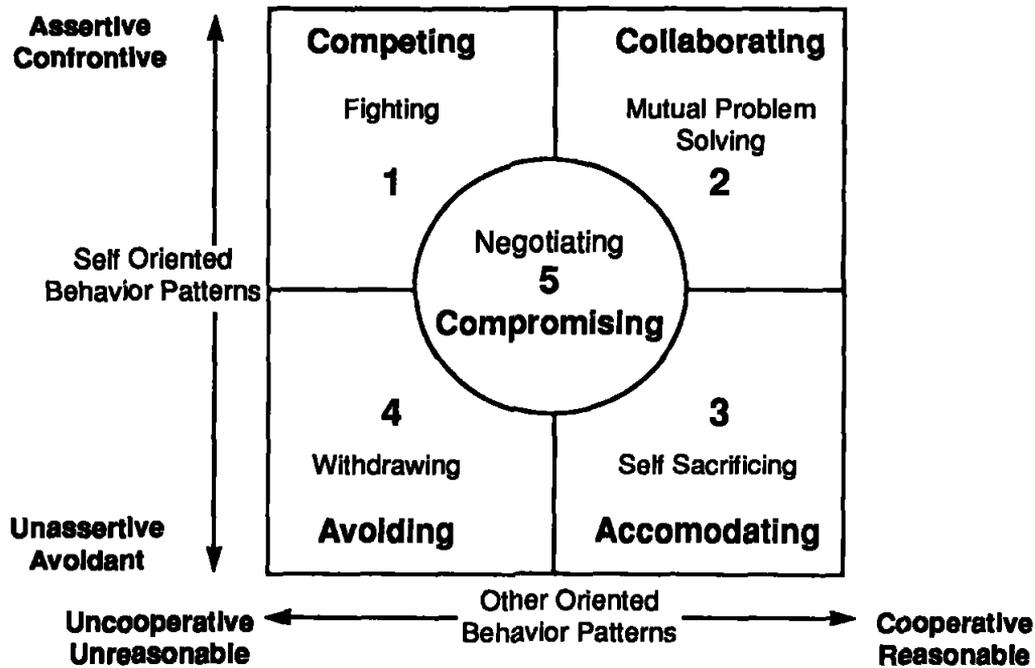


Figure 6: Conflict Patterns



specific assets and liabilities, and the consequences of using a particular style too little or too much. As shown in the model, two basic variables are plotted against one another (1) assertiveness, the extent to which the individual attempts to satisfy his or her own concerns, and (2) cooperativeness, the extent to which the individual attempts to satisfy the other person's concerns. These two dimensions define five distinct styles for coping with conflict: competition, collaboration, avoidance, accommodation and compromise.

Which Pattern Or Style To Use

Nothing is inherently right or wrong about any of the conflict-management styles; each may be more or less appropriate and effective, depending on the situation and the parties involved.

Each of us has access to a variety of conflict-management behaviors but we tend to perceive certain ones and use them to the exclusion of others that could be more effective in a given situation, often with adverse consequences. We must develop the

skills to execute any of the styles. Then we can diagnose conflict situations and choose the appropriate way to deal with whatever come up, depending on our needs at the time and the importance of coming to a resolution within a prescribed time frame.

Whether a particular conflict-management pattern or style is appropriate is specific to the people and context of the conflict situation. To be effective at managing conflict, one should be able to use any of the styles and know when each style is appropriate. However, people tend to develop one preferred or default style and use it in most situations. As a consequence, people may neglect styles that could be more effective.

Steps For Collaborative Conflict Resolution

1. Explain the situation the way you see it. Emphasize that you are presenting your perception of the problem. Specific facts and feelings should be used if possible.

2. Describe how it is affecting performance. Keep attention on the work-related problem and away

from the personalities involved. Present the problem in a way that will be readily understood, and concentrate on important issues.

3. Ask for the other viewpoint to be explained. Before proposing solutions, gather as much information as possible. This step confirms that you respect the other person's opinion and need his or her cooperation. Listen carefully while he or she talks and be open to learning and changing.

4. Agree on the problem. Summarize the various viewpoints and state clearly the problem that you and the other participant(s) think needs to be solved. Once both parties agree on this, they can more easily focus on developing solutions.

5. Explore and discuss possible solutions. To ensure shared ownership of the problem's resolution, all participants in the conflict should be involved in developing solutions. The synergy developed may result in better solutions than any participant would have produced alone.

6. Agree on what each person will do to solve the problem. Every person involved must clearly understand his or her role in the solution and accept responsibility as an individual and team member for making it work.

7. Set a date for follow-up. A follow-up meeting allows you to evaluate progress and make adjustments as necessary. People are much more likely to follow through if they know they will be held accountable for their commitments at a follow-up meeting.

Some Communication/Process Requirements For Successful Conflict Resolution

1. Focus is on defeating the problem, not one another.

2. Everyone is involved in the process to create a sense of shared responsibility for the solution.

3. Solutions are evaluated in terms of quality and acceptance to the parties.

4. Questions are asked to elicit information, not to belittle the other party.

5. Feedback is descriptive, specific and non-judgmental.

6. Power is equal or power differences are

ignored.

7. Information is shared equally by everyone.

8. Parties believe that mutually acceptable solutions are possible and desirable.

9. Parties trust each other, are not defensive, angry or threatened.

10. Parties do not make a "we-they" distinction; instead it's "we vs. the problem."

11. Problems are jointly defined by the parties.

12. Problem description, solution generation and solution evaluation are separate phases of discussion.

Key Learning Points

Conflict has both positive and negative consequences for an organization and for an individual. The absence of conflict can be as dysfunctional as excessive amounts of conflict.

There are five basic conflict styles, all of which have potential uses. Choosing the appropriate style to use depends on the situation at hand.

Thoroughly analyzing a conflict situation is vital to ensure that an appropriate resolution strategy is used. Control and confrontation are both legitimate strategies.

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Economic Impact of Bull Choices... A.I. Or Otherwise

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Profitability from bull selection and other reproductive technologies such as embryo transfer will vary from herd to herd. Much of the differences will depend on how carefully the economic consequences of the various decisions made when choosing among alternatives are evaluated. For instance, if the highest-priced bulls are used under the assumption that semen price is almost perfectly correlated with true value for commercial milk production, profitability from the selection program will be low and probably nonexistent. Using natural service just because it is perceived to always be more cost efficient will often lead to less profitability than use of A.I. Provided that replacement heifers are to be reared from calves born on the farm, a carefully planned A.I. program usually, but not always, will be the most profitable breeding strategy.

One of the few exceptions to the potentially superior profitability of A.I. would occur if replacements of equal quality can be purchased cheaper than yours can be reared. Whether A.I. should be practiced in such a situation would depend on its effect on sale price of calves a few days old compared to any extra costs of A.I. over natural service and safety considerations. The latter may be important if dairy bulls are used naturally.

Another caveat is that common sense is used when buying and using semen. Buying semen from the currently "hot" and usually overpriced bulls to breed ordinary grade cows is not sensible. Despite the hype that usually surrounds such bulls, few if any will sire the most profitable commercial replacements. Some may, however, win the local cattle shows but how many commercial dairy producers show cows today?

Using expensive semen to inseminate cows that are likely to be culled before they calve again or those of low or questionable fertility does not fall within my

definition of common sense either. Breeding heifers to bulls known to cause a high percentage of difficult births of 10% or higher is in the same category.

How should semen be chosen to maximize profitability? The best procedure is to use an index such as Net Merit published by USDA as the first screen. First, this measure includes a bull's genetic values for milk, protein, and fat minus the feed costs needed to obtain the extra outputs. If the ratio of your expected FUTURE prices for protein and fat differs from the national averages used by USDA, it is a relatively simple matter to adjust for your market. Please note that unless the ratios of prices among milk, fat and protein change there is little advantage

in recomputing the index. Even if you plan to breed or buy bulls to use in natural service, you should apply the same procedure to their pedigree values to decide which ones to use.

The second part of the Net Merit index, PTA for Productive Life, also has major economic value. Longer productive life means both more months of production per cow and fewer replacements, thereby diluting the net cost of replacements per lb. of milk produced. The USDA PTA for this trait for Holstein cows also takes account of the effect of type traits on survival rates or longevity, a modification that is especially valuable for bulls with

only young daughters.

The PTA for Somatic Cell Score (SCS), the third part of the Net Merit index, will almost surely be more important in the future than it is now weighted in the index. This statement is made because recent research at North Carolina State shows that daughters of bulls with desirable (low) PTAs for SCS live longer than those with higher values. Our results showed PTA-SCS to be slightly more closely related to length of life than PTA-Milk was. The value of a higher survival rate is not now included in the value

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assigned to PTA-SCS in the Net Merit equation. Also, quality premiums for low SCC milk and penalties for higher SCC are almost surely to increase in the future.

Admittedly, we have much to learn about the optimum use of PTA-SCS, but I am convinced that the more we learn, the higher the economic value of the trait will become. This does not mean that we will control clinical and subclinical mastitis by genetics, but simply that it will become part of the strategy for keeping them minimized.

Recent research at Virginia Tech has verified the considerable economic value of conception rate of semen. The limitation to using the currently available measure of it, Estimated Relative Conception Rate (ERCR), is that it can only be computed accurately after the bull has been in service for a year or two.

Differences of 5% in ERCR are common among active A.I. bulls. To put this in perspective, the true conception rate of Holstein cows is usually 40-50%. An ERCR of +5 means that 5 more cows per 100 serviced will become pregnant, a true advantage of at least 10%. This translates into about a 10% reduction in the cost of a conception, not an insignificant amount. Holstein heifers are more fertile, perhaps as much as 65-70%, so ERCR is not quite as important when breeding them, but a 5% difference still is not trivial. Provided calving difficulty of a bull is not too high, the most profitable place to use bulls with many desirable traits, but a below-average ERCR, is to breed them to heifers.

Breeding heifers to bulls siring calves that are born with little difficulty (7% or lower calving difficulty) is an economically desirable practice provided not too much is given up in other traits. Luckily, low calving difficulty, high milk and high survival are favorably correlated. The younger heifers are bred, the more important it is to choose for low calving difficulty among bulls high on Net Merit. However, it does not make sense to sacrifice everything else to get low calving difficulty if the resulting heifers are to be reared as replacements.

In the past it was commonly thought that breeding to a beef bull was a surefire way to have low calving difficulty. Today, many beef bulls cause

much calving difficulty and must be chosen as carefully as dairy bulls to reduce it.

Even if replacements are not to be saved, remember that losses are higher in heifers having calving difficulty from increased deaths, personnel costs, lower milk, and poorer rebreeding rates. This means it is profitable to choose bulls to minimize calving difficulty when breeding heifers. This holds regardless of what type of bull – A.I. dairy, A.I. beef, natural service dairy or beef – is used.

Bull choices that will lead to inbreeding usually will be less profitable than those giving outbreeding. Matings that will produce inbred fetuses have a reduced success rate. A fetus that is inbred has up to a 50% higher chance of dying before birth than a non-inbred one. A common misconception is that inbreeding only affects calves after they are born, but the truth is that the detrimental effect starts the day an inbred mating is made. Conception rates from inbred matings will be lower, as well as survival to implantation and any later stage of pregnancy. Bluntly, the economic effects of inbreeding in dairy cattle are often underestimated. Just ask any pig or beef producer why they usually crossbreed and you will find out why.

My rule of thumb is that for an inbred mating to be justified the predicted economic value of a resulting calf has to be at least 1% higher than the best non-inbred mating for each 1% more inbreeding that it will cause. I challenge anyone to provide data based on a complete economic analysis that refutes this. Analyses based on "inbred" cows that survive to lactate have ignored most of the true costs of inbreeding. An advantage of A.I. is that many bulls representing a wide variety of lines are available, so inbreeding can be minimized.

One of the false ideas used to support natural service is that it is practically free. This false idea arises because all direct costs of using bulls are rarely considered, let alone the indirect and opportunity costs. Research several years ago at the University of Wisconsin by Shook showed that the direct costs of natural service in a typical herd averaged \$18 per service. With the larger herds typical today, this may

be a few dollars too high, but natural service is still costly. Low conception rates and diseases may also be obtained from such bulls.

Among the indirect and usually ignored costs of natural service over A.I. are more inbreeding and imprecise knowledge of expected calving dates. Unless cows can be grouped by their genetic relationships, which is impractical in most herds, some inbred matings will be made leading to the losses discussed earlier.

If expected calving dates are not known, dry periods will not be of the economically best length. Also, dry cows will not get the management necessary to maximize future profitability.

For A.I. to be profitable, management adequate to detect accurately at least 40-50 percent of true heats is essential. Without this minimum level of accuracy, a high percentage of cows will be missed until their lactation is advanced. Obviously, long open periods predispose a cow to premature culling.

A common misconception is that 70-80% of heats must be detected to use A.I. successfully. Actually, only the best managed herds reach that level. Studies by Blake and colleagues at Cornell showed that increasing accurate heat detection rates beyond 50% was often unprofitable. This occurred when costs to obtain the extra accuracy amounted to more than a few dollars per additional cow detected.

Accurate identification of individual cows is also essential. Otherwise, cows may be misclassified as in heat when they are not. Inaccurate identification of the cows truly in heat usually has drastically unprofitable effects. Results will be unnecessary costs without additional pregnant cows. Breeding cows not in heat may also be harmful to the future reproductive success of a cow and provides zero return on semen and other costs.

Consequences of inadequate or inaccurate heat detection will be costly. Long calving intervals will be common. Yields of many cows will decrease to unprofitable levels before they become pregnant.

Research several years ago at the University of Wisconsin showed that the direct costs of natural service in a typical herd averaged \$18 per service.

Combined, these may negate some of the favorable aspects of A.I.

Limitations of facilities may affect the profitability of A.I. When it is expensive to catch and restrain cows for breeding, costs per pregnancy increase. If catching and restraint upsets cows, conception rate can be reduced. This may reduce the pregnancies resulting per A.I. service, thereby increasing their cost. New Zealand, which has one of the world's lower fixed

cost per cow, breeds nearly 70% of its cows by A.I. This shows that adequate facilities for A.I. need not be expensive.

Another common misconception is that conception rate to A.I. service must be over 50% for A.I. to be profitable. At 40% conception, only 34% of cows will require three or more services. Only 10% will need more than four inseminations. The realistic upper limit of conception rate is only 65-70% with natural service to a highly fertile bull. For example, pregnancy rate is rarely more than 80% in cycling cows exposed to a fertile bull for 50-60 days. Usually higher conception rates will make A.I. more profitable, but an outstanding conception rate is not necessary to make A.I. more profitable than natural service.

The opportunity costs of using natural service are well known. The USDA summaries released after every sire summary show that the net value of the extra milk of an A.I.-sired cow is worth at least \$25 over feed costs in each of her three or more lactations. This occurs because feed costs for maintenance and fixed costs are nearly the same for every cow of the same age and body size. The total additional net of \$75 per cow over her life should be mostly profit because costs of A.I. can be kept near that of natural service by good planning and management.

How much one can profitably pay per unit of semen over the cost of natural service has been the subject of much research and discussion without an answer that satisfies everyone. General agreement

has been reached that the expected net financial return from the resulting heifers is the best method of computing how much can be paid. Disagreement still remains on details of some of the minor costs and returns that should be included.

The main factors affecting expected or predicted income are:

1. Expected additional lactation yield of a cow resulting from the semen of a particular bull.
2. Future values of milk and its components.
3. Expected length of a resulting cow's productive life.
4. Conception rate of semen as it affects the probability of a heifer calf.

5. Values of any traits such as mastitis resistance, ease, labor or speed of milking, calving difficulty, etc., that reduce costs over that of an average cow.

The main factors affecting variable and A.I. costs are:

1. Expected future feed costs per unit of milk and components.
2. Minimum cost of getting a cow pregnant by A.I. minus cost of a pregnancy from natural service.
3. Extra cost of semen from a particular bull necessary to obtain a milking heifer, discounted for the time value of money.
4. Opportunity costs from any milk lost due to calving intervals longer than those from natural service.

You may note that only the additional cost of semen is affected by conception rate. Whether the cow will be kept to calve, calf liveability, and all other costs affect A.I. and natural service equally.

Comparing Profitability of A.I. and Natural Service for a Herd:

A simple but reasonably accurate comparison of the relative profitability of A.I. and natural service breeding may be obtained by the following steps. Estimate or compute the following:

- **Expected value of milk and its components in your future milk market for a lactation from an average daughter of the A.I. bulls available, minus the values for an average natural service daughter. Multiply by 3.0 for lifetime value.**

- **Add in the value of superiority for additional traits of the A.I. bulls, including udders, feet, SCS, and longevity. Multiply by 3.**

- **Compute value for feed costs of the extra milk, which usually varies from 35-40% of the milk value.**

- **Compute the costs of getting an A.I.-sired heifer minus the cost of a naturally sired one.**

The approximate profitability of A.I. for your herd is simply:

Number of replacements per year times [(1 above)+(2)-(3)-(4)]

or:

Number of replacements x (milk \$+ \$value of other traits minus feed costs for extra milk minus extra cost of an A.I. daughter).

For example, suppose the following costs and returns are appropriate for your herd:

a. Many studies have demonstrated the genetic superiority of A.I. bulls over those used in natural service. Daughters of first-proof A.I. young bulls average about 400 lbs. more milk than those of first-proof natural service bulls from USDA summaries based on differences in USDA PTAs. This is worth about \$40. For a lifetime multiply by 3.0 to equal \$120.

b. Suppose superiority in other traits adds \$15 per cow over her life.

c. Suppose extra feed costs are 40% of milk, or \$48 over the cow's life.

d. Suppose the extra cost of obtaining an A.I. daughter is \$50. This would include the extra labor and supplies over natural service costs.

The net value of A.I. is now \$120+\$15-\$48-\$50, for an advantage of \$37 per cow. For 100 replacements the total would be \$3,700. This does not include any additional value the A.I. daughter might have for other traits or if sold as a replacement. It also assumes that there is not any value in knowing when a cow is due to calve, a bit of information I believe most producers would agree has some usefulness.

Let us now see if the \$50 extra cost of getting an A.I. daughter is reasonable. Assuming the cost of the natural service bull is \$12 per service, and 5.0 services are required to get a milking heifer by natural service, base breeding costs are \$ 60.

Now let us look at A.I. costs. Because our example is based on only using young A.I. bulls, the semen cost per service would not be more than \$5 and probably less. Assuming other A.I. costs are \$9 per service, and 8.0 services are needed because of lower conception rate, we have an overall cost of \$110. This totals \$50 more for the A.I. heifer. The

costs used are probably too low for natural service and too high for A.I., but it still appeared to be more profitable. I believe A.I. to be a profitable investment.

In my opinion this simple example justifies my opening statement that A.I. will practically always be more profitable than natural service if replacements are to be saved.

The same general procedure can be used to compare any groups of bulls, or even two individual bulls.

notes

Managing The Milking Parlor For Profitability

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The trend toward larger dairy farms is occurring in every region of the U. S. For example, in the two largest dairy states, California and Wisconsin, average herd size since 1950 has increased 950% and 290%, respectively (5). Similar trends can be seen in most other states. Today dairy herds in excess of 500 cows are common in all parts of the U. S. and herds over 1,500 cows are quite common in the Southeast and West.

An important factor which determines maximum herd size on the majority of large dairy farms is the number of cows which can be milked per day by the milking parlor. Therefore, selecting milking parlor size in new or renovated facilities is an important business decision which will impact the volume and profitability of the dairy operation for many years. In theory the formula for profitable milking is simple: combine optimal quantities of genetically superior dairy cows with properly designed milking equipment and facilities manned by highly trained and motivated employees. However, in practice the information available to guide dairy owners/managers in predicting the level of economic performance to anticipate from various parlor sizes and designs is scarce and confusing. Also, very little is available describing the best parlor management strategies (i.e., milking procedures, amount of milking labor) required to insure optimal return from the milking parlor investment.

Recent research at the University of Florida^{7, 8, 11} has focused on integrating production and economic variables to determine more profitable dairy management strategies. This paper will focus on research investigating milking parlor profitability¹¹. Several common decisions the dairy owner/manager must consider in order to achieve maximum milking operation profitability will be examined, including:

- 1) pre-milking hygiene routine,
- 2) level of milk production,

- 3) milking frequency,
- 4) parlor size and configuration.

Double-20 and double-40 parallel parlors, which are common on large dairies, will be used in all comparisons.

Materials And Methods

It is nearly impossible to apply traditional experimental methods to complex systems like milking parlors. Also, it is not economically feasible to alter operating parlors to answer a variety of "what-if" questions. Therefore, we examined milking parlors using a technique called simulation modeling. Simulation modeling is a technique in which the real system (i.e., milking parlor, milking system, cows, and milking personnel) is imitated by a computer program. The computer program contains all of the logical and quantitative relationships between the milking parlor, milking system, cows, and milking personnel necessary to provide an accurate abstraction of the actual milking parlor system.

Our parlor simulation model⁸ was built from data collected from over 60 large dairies. These data included survey data and over 100 hours of videotapes of large milking parlors in operation. The parlor simulation was validated by comparing it with the actual performance of parlors on four large Florida dairies. Table 1 indicates that the parlor simulation model was extremely accurate in predicting actual parlor performance for each of these four dairies with less than .5% difference between actual and simulated averages for number of cows milked per hour (CPH) or pounds of milk harvested per shift

Table 1: Comparison between actual and simulated milking parlor performance for four large Florida dairies.

dairy	parlor design	parlor size	actual CPH ¹	simulated CPH	actual MPS ² (lbs)	simulated MPS (lbs)
A	herringbone	D-16	164.63	164.80	19,908	19,886
B	herringbone	D-20	206.60	207.60	32,509	32,628
C	parallel	D-35	320.20	319.20	46,176	46,077
D	parallel	D-40	362.51	361.60	59,467	59,745

(¹ CPH = number of cows milked per hour.)

(² MPS = total milk harvested per 3X milking shift.)

Table 2: Costs of totally equipped parlors including parlor building and associated equipment.

parlor	building area ¹ (ft ²)	building ²	parlor equipment ³	milking equipment ⁴	automation equipment ⁵	Total
Double-20 herringbone	11,833	\$248,493	\$184,245	\$64,343	\$57,629	\$554,710
Double-20 parallel	10,824	\$227,304	\$180,737	\$62,744	\$49,990	\$520,775
2-Double 20 parallels	21,428	\$449,988	\$322,318	\$114,930	\$99,980	\$987,216
Double-40 parallel	20,064	\$421,344	\$310,631	\$133,034	\$99,980	\$964,989

1: Building area includes wash and drip pens, cow platform and operator pit, milk room, equipment and service area for vacuum and refrigeration systems, office and adjacent restroom and storage area.

2: Based on a cost estimate of \$21/ft² of floor area which included all electrical and plumbing with poured concrete walls and modular metal roof construction.

3: Parlor equipment included stalls, gates, milk cooling and wash systems, and crowd gate.

4: Milking equipment included milking units, pulsation and vacuum systems, milk line, and receivers.

5. Automation equipment included automatic detachers.

(MPS) on 3x/d milking.

The parlor simulation model was capable of examining the effects of milking parlor design (herringbone vs parallel), milking parlor size (double-16 to double-40), milking system operating characteristics (vacuum: 12.5, 13.8, and 15.0 in Hg; pulsation ratio: 50:50, 60:40, and 70:30), milk yield, amount of milking labor, and milking procedures on milking parlor physical performance (i.e., cow throughput and milk output).

Additionally, a capital budget model was formulated⁸ to examine the long term economic implications of selecting alternative parlor sizes, designs, and operating strategies. The budget model calculated the after-tax net present returns to ownership and non-parlor fixed costs (NPR) over a 15 year lifespan for each parlor. This budget model accounted for all revenues (e.g., milk, cull cows, and calves), all variable costs (e.g., feed, replacements, utilities, parlor supplies, veterinary and medicine, breeding, milk marketing, repairs, etc.), and all fixed costs (e.g., parlor construction, insurance, property taxes, etc.).

Costs of totally equipped parlors are given in Table 2. All economic results reflect Florida's seasonal milk price and production and all comparisons were made at a 21,000 lb rolling herd average milk production.

The studies reported in this paper examined four issues relevant to the operation of large milking parlors: 1) pre-milking hygiene routine, 2) level of milk production, 3) milking frequency, 4) parlor size and configuration. Each issue was examined for its effects on parlor physical and economic performance. Two pre-milking hygiene routines compared were: 1) a full routine (Full) which included stripping, pre-dipping, drying with cloth or paper towels, and unit attachment, and 2) a minimal routine (Min) which only consisted of unit attachment. Both routines employed post-dipping.

RESULTS

Pre-milking Hygiene Routine

The decision of an owner/manager to incorporate a certain pre-milking hygiene routine is usually

determined by facility design and animal health (mastitis) concerns. Previous comparisons of CPH reported by Armstrong et al. (2) in parallel parlors showed that the full routine (Full) reduced parlor performance by 15-20% in double-20 to 24 parallel parlors. In the comparisons reported here cows were milked 3x and RHA was 21,000 lbs/cow. Our purpose is not to recommend one pre-milking hygiene routine over another, but to give dairy owners/managers an indication of the effects the two routines have on parlor physical and economic performance.

Table 3 presents the effects of the two routines on physical performance (CPH) and economic performance (NPR) for Full and Min pre-milking hygiene routines. Parlor physical performance (CPH) increased as the time required for pre-milking hygiene decreased (Min). This is expected because going to the Min routine eliminates pre-milking tasks that require over 8 seconds per cow to perform. When the Min routine was substituted for the Full routine, CPH increased 21% in the double-40 (317 vs 383 CPH) and 39% in the double-20 (186 vs 258 CPH). Higher physical performance (CPH) resulted in more milk output per day with a corresponding increase in parlor economic performance (NPR). The lifetime return potentials for either parlor increased over \$1,250,000 by switching to the simpler routine. The percentage increase in performance for larger parlors to Min pre-milking routine will be less than smaller parlors. This is due to the fact that larger parlors are generally less efficient than smaller parlors because they have a greater opportunity for a breakdown in milking routine and any problems will delay the turn around time of more cows in the large versus small parlor.

Level of Milk Production

Rolling herd averages increase yearly in most dairy herds. Fifty pounds of milk per milking cow was an acceptable average in the 1950-60's. However, future levels of average milk production per milking cow will exceed 90 lbs or more. Research

Table 3. Comparison of full pre-milking hygiene routine (full) and minimal routine (min) on cows milked per hour (CPH) and net parlor returns (NPR) for D-40 and D-20 parallel parlors.

routine	parlor size	CPH	NPR ¹
full	D-40	317	\$3,536,686
min	D-40	383	\$4,822,033
full	D-20	186	\$2,222,813
min	D-20	258	\$3,475,124

(1: Rolling herd average equals 21,000 lbs on 3x milking, milk price at \$12.00/cwt. Returns are discounted over the 15-year expected useful life of the parlor.)

(9) has shown that milking time is heavily influenced by milk yield per cow. For example, a 1986 study (1) showed that the physical performance (CPH) of a double-8 herringbone decreased 25% when milk yield per cow increased from 35 to 61 lbs./cow/day. Therefore, it is extremely important for dairy owners/managers to select milking parlor size for new or renovated parlors to accommodate the increased levels of milk production anticipated over the expected life of the parlor.

Table 4 shows the effect of two RHA (22,000 and 25,000 lbs.) and milking frequency (2x or 3x) on parlor physical performance and parlor gross returns per month. Pre-milking hygiene in the double-40 and double-20 was Full. The results in Table 4 show that parlor physical performance was only slightly affected when RHA increased 3000 lbs. In the double-20 and double-40 parallel parlors there was almost no change in CPH for 2x milked herds when RHA increased from 22,000 to 25,000 lbs, and about a 2.5% decrease when RHA increased for 3x milked cows. A 2.5% decline in parlor throughput may appear small; however, if herd size is around 3000 cows it means you can milk 75 less cows per day. When the income from these 75 cows is lost there is no corresponding reduction in parlor fixed costs and a nearly imperceptible reduction in variable costs. Furthermore, a change from 22,000 to 25,000 lbs on RHA is only about a 14% increase. The percentage increase in RHA over the 15-year life of a parlor investment should be anticipated to be much higher.

Milking Frequency

Machine-on time is greater per milking for 2x cows compared to the same cows milked 3x due to higher milk yield per cow per milking. However, 3x cows have a lower average flow rate due to lower milk yield per milking. Data from several double-20 and 30 parallel parlors has shown that steady state throughput is 8-10% higher for herds milked 3x versus 2x². A previous study evaluating the economics of 3x versus 2x milking³ indicated that a response of 12-15% and a milk price over \$14/cwt was necessary for 3x to be more profitable than 2x. This study did not consider fully utilizing parlor capacity to maximize parlor output.

Table 4 shows there were large decreases in CPH when milking frequency went from 3x to 2x at either RHA. Going from 3x to 2x at 22,000 or 25,000 lb RHA in either the double-20 or double-40 parallel parlor resulted in a 10-12% drop in CPH. These results show that it is critical to match parlor capac-

ity to the anticipated milking frequency. Investigation of parlor gross returns (Table 4) showed, as expected, that more gross income is generated by higher RHA, but gross income is also increased by milking 2x versus 3x because more total cows can be milked 2x. Labor costs were the same on 2x and 3x because the total shift length, including set-up and clean-up, resulted in 24 hour/day parlor operation. Also, parlor fixed costs are unaffected by milking frequency. However, a 2x dairy would generate more costs due to larger land base requirements, expanded housing facilities, and greater waste disposal requirements due to the expanded herd size. Further economic studies of 2x versus 3x on large herds are needed, because even if profit margins on 2x cows are lower, total profit may be larger if parlor throughput can be increased to adequate levels to accommodate larger herd sizes.

Parlor Size and Design

Milking parlor performance data from time and motion research¹ and simulation studies⁸ has indicated that parlor performance efficiency decreases as a result of: 1) increased parlor size, and/or 2) parlor design (herringbone vs parallel)^{3, 8}. Parallel parlors outperformed similarly sized herringbones^{1, 8}. Thomas⁸ showed that double-16 and double-20 parallel parlors outperformed their herringbone counterparts by about 13 CPH. This research also indicated, as shown in Figure 1, that smaller parallel parlors (i.e., double-16 and double-20) operated more efficiently than larger parallel parlors (i.e., double-32 and double-40). For example, a double-20 parallel parlor operated over 18% more efficiently than a double-40 parallel.

The primary reason for decreased performance with increased parlor size would be due to the interaction between parlor size and the time required to perform individual parlor tasks. All parlor tasks require a relatively short time to perform. For exam-

Table 4: Effects of rolling herd average (RHA) and milking frequency on physical and economic performance of double-20 and double-40 parallel parlors.

milking frequency	RHA ¹	herd size ²	CPH ³	gross\$/mo. ⁴
		double-20		
2x	22,000	2046	186	479,294
2x	25,000	2046	186	503,511
3x	22,000	1518	208	343,736
3x	25,000	1482	203	355,840
		double-40		
2x	22,000	3784	344	871,443
2x	25,000	3751	341	910,174
3x	22,000	2781	381	626,955
3x	25,000	2716	372	648,741

1: Rolling herd average, lbs/cow/year

2: Herd size equals number of cows that can be milked per 11-hr shift (2x) or 7 hr, 20 min shift (3x).

3: CPH = cows milked per hr

4: Gross milk income per month @ \$12.00/cwt

ple, it took about 4 seconds to attach a milking machine in a parallel parlor. However, a small percentage of the time it took perhaps 15-20 seconds. The same situation arises for all parlor tasks in that a small percentage of the time they will take much more time than usual. Since parlor tasks are performed sequentially, a task that requires a very long time will delay the performance of subsequent tasks and ultimately increase the overall cycle time for the cows currently in the parlor. This effect is even more detrimental to parlor performance as parlor length increases because a greater number of cows are affected. Plus, the possibility of a task taking a lengthy time increases as the parlor becomes larger simply because there are more opportunities for it to happen within a given milking cycle.

Parallel parlors enjoy a number of advantages over the herringbone. In parallels cows have over 35% less distance to travel to enter the parlor as compared to a herringbone parlor. This shorter distance reduces the first cow entry time by over 4.5 seconds in a double-16 and nearly 6.0 seconds in a double-20. In parallels the time required for milkers to walk between stalls during premilking preparation and machine attachment is also less and the average time to attach machines is generally 1.5 to 2.9 seconds shorter than in herringbones¹. Individually these differences appear small; however, they are additive and thus increase work routine time and decrease parlor operating efficiency in herringbones. These differences in cow entry time and work routine also will allow the same number of

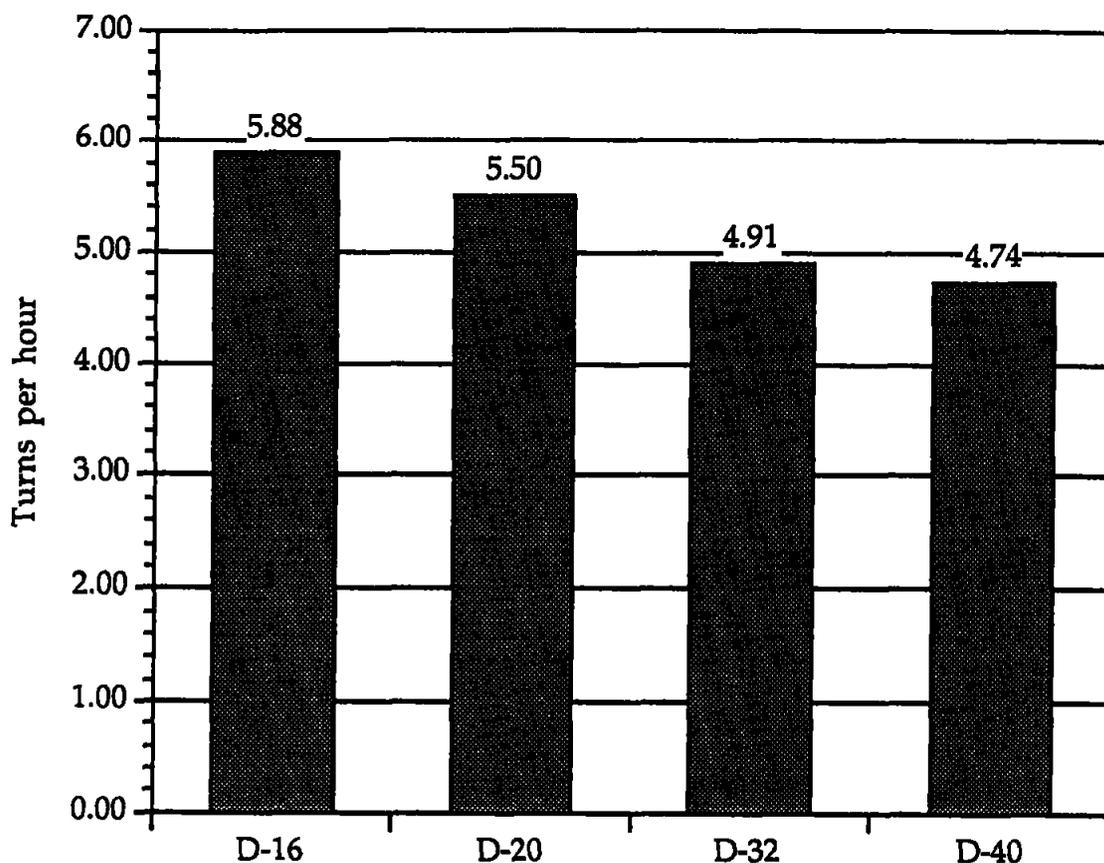


Figure 1. Performance comparison of four large parallel milking parlors.

operators to effectively utilize more milking units in a parallel versus herringbone parlor.

Table 2 presents cost estimates in the southeastern and southwestern U. S. for construction and equipment for double-20 parallel and herringbone parlors. The difference of \$34,000 in cost only represents 6.5% of the totally equipped parlor cost. Using a 15-year planning horizon, 7.5% discount rate, and 34% tax rate, the difference in net parlor returns (NPR) favor the parallel by about \$688,950. This economic advantage has little to do with the relatively small advantage the parallel enjoys in initial cost, but is primarily the result of its higher operating efficiency which allows higher cow throughput and thus a larger herd size to be maintained over its entire useful life.

Parlor costs for two double-20 and a single double-40 parallel parlor(s) are presented in Table 2. The difference in initial cost is \$22,227 or 2.3% of the total initial cost. If the dairy design was an open corral with shade design typical of the southwestern U. S. the difference in corral costs for smaller pens necessary for the two double-20's compared to larger pens for a single double-40 would be approximately \$60 per corral for extra lanes, fences, water tanks, etc. Table 5 shows the physical (CPH) and economic (NPR) performance for two double-20 parallels versus a single double-40 parallel. Differences in total corral costs are included. The advantage of 17% in CPH and 26% in NPR for two double-20's should be a major consideration for dairy owners/managers planning new parlor facilities or considering renovations of existing parlor facilities.

Conclusions

Selecting a milking parlor(s) is a major management decision because the choice will determine maximize herd size and impact profitability of the dairy farm for many years. Parlor design and size and management decisions on frequency of milking and pre milking hygiene routine all need to be considered in this decision. Future levels of milk production during the expected lifetime of the parlor should be considered but will be of less importance

Table 5: Comparison of two double-20 parallel parlors versus a single double-40 parallel parlor for cows milked per hour (CPH) and net parlor returns (NPR).

	CPH ¹	NPR ²
two double-20 parallels	371	\$4,445,625
double-40 parallel	317	\$3,536,686

1 Both parlors used Full pre-milking hygiene routine and 3x milking.

2 Based on RHA of 21,000 lbs per cow and \$12/cwt. milk price. Net parlor returns are discounted over the 15-year expected life of the parlor

than other factors.

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notes

Economical Feeding And Management Practices For Herds Approaching 30,000- Pound RHAs: A Panel Discussion

Panelists:

*Brad Houston, Price's Roswell Dairy,
Roswell, NM,*

*Dennis Lagler, Lagler Dairy,
Vancouver, WA*

Moderator:

Don Bath

*Extension Dairy Nutritionist Emeritus,
University of California, Davis, CA.*

Generally speaking, high milk yields per cow are associated with greater profitability of the dairy enterprise. Average milk production per cow has more than doubled since the 1950's. Many lower producing dairy herds have gone out of business during that period, while the more efficient herds have expanded tremendously. However, not all high producing herds are profitable because profitability is dependent on economical inputs as well as high milk yields. The panelists in this discussion are dairy managers who run two of the highest producing herds in their respective states, Washington and New Mexico. They give their views on feeding and management practices that result in economical milk production in extremely high-producing herds.

Briefly describe your herd

Houston:

Price's Roswell Farms has been in the Pecos Valley of New Mexico since 1945. We have a grade herd of cows but have concentrated on a good genetic base. Artificial insemination has been used in our

herd since the arrival of frozen semen. Before that, we collected our own bulls and bred A.I. We are on DHIA official testing and our records are processed at DHI-Provo. Our current DHIA rolling herd average is 23,781 lb. of milk on 1,522 cows. We also have about 1,800 calves and heifers on the farm.

Lagler:

Our dairy is in Vancouver, WA, just outside of Portland, OR., 17 miles from Portland International Airport. Although we are 2nd generation on this site, we are fast becoming "urban" farmers. (four lanes of traffic and sidewalks in front of our milking parlor). Dad and Mom moved from Tillamook, OR, in 1955 and Jan and I began buying the farm from them in 1975. We have 535 cows in the herd, about 475 milking. We raise all our replacement heifers and sell the bull calves. We have 600 head of young stock. Currently, our rolling herd average is 25,946 lb milk with 814 lb protein.

Do you raise your own heifer replacements? If so, describe your calf management system.

<p>BIRTH Colostrum – (1 gallon first 12 hours) Intranasal vaccine iodine Navel – (7% Iodine) Selenium Shot – (1cc)</p> <p>WEEK 5: IBR BVD PI₃ BRSV</p> <p>WEEK 11: Respiratory Vaccine – (1 shot vaccine)</p> <p>4 MONTHS: 7-Way Clostridial/Hemophilus Somnus</p> <p>6 MONTHS OR BEFORE: 4-Way Virus 7-Way Clostridial/Hemophilus Somnus</p> <p>PRE-BREEDING: (1 month) IBR BVD P13 BRSV LEPTO 5 7-Way Clostridial/Hemophilus Somnus</p> <p>PREG CHECK: Lepto 5</p> <p>SPRINGERS</p>	<p>Routine Dry Cow Program: Endovac-Bovi 2 Shots 7-Way Clostridial/Hemophilus Somnus Selenium Shot (5cc)</p> <p>FRESH COWS (1-3 weeks) IBR BVD PI₃ BRSV</p> <p>PREGNANCY EXAM: LEPTO 5 – (when pronounced pregnant)</p> <p>DRY OFF: Reconfirm pregnancy Dry Cow Treatment Endovac-Bovi 2cc IM Dry-off time and 2 weeks later first year; 1 shot following years 7-way Clostridial + Hemophilus somnus</p> <p>1 MONTH PRIOR TO CALVING: Selenium shot – (8cc IM and 2 weeks later) Rotavirus, Coronavirus, E. Coli and Clostridium perfringens Type C</p> <p>2 WEEKS PRIOR TO CALVING: IBR BVD PI₃ BRSV Second shot of virus, E. Coli and Clostridium</p>
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Houston:

We maintain a closed herd and raise our own replacements. Calves are raised in hutches for one month and then moved to pens in groups of eight. Calves are fed with bottles; colostrum milk is checked with a colostrometer for quality. The best milk is fed to the youngest calves. We do not feed any mastitis or sick cows' milk to calves. Calves are weaned at three months. Dehorning is done at three weeks, and the horn buds are burned with a portable butane-powered dehorner. An extensive vaccination program is administered to the herd under the supervision of our veterinarian as outlined on the facing page.

Lagler:

Presently we are starting heifers in hutches, then move them to group pens. As they get older, they are placed in another group at a different location. And finally, regrouped at the other location and returned to the farm. We need a freestall barn with lockups for better supervision and better conditioning into top producers. We feed primarily grass silage and alfalfa hay to encourage larger size. Corn silage puts on weight, but not enough size. Presently we breed the heifers to calve at 24 months. In the future we want to increase the size and frame of the animal so we can reduce the calving age. If we could keep our springing heifers separate from our other dry cows, we could feed them to grow (and the mature cows wouldn't gain too much weight.)

We need better heifer facilities to take better care of heifers.

What are the factors that you feel are important in your breeding program?

Houston:

I feel strongly that a large cow is needed to handle the nutrients required for high milk production. For the same reason, I generally use calving ease bulls that are eights or nines. All cows and heifers are evaluated for sire recommendations. July 1994 guidelines are +1200-TPI; +300 protein \$; +80 lb. protein; +1.5 type; and +1.00 udders; +.01 legs;

+1.00 body depth; +1.5 dairy composition. I make a few exceptions to these guidelines so that I can get enough bulls. We breed first choice twice, second choice once and then we go to young sires. Heifers are bred to calve at 24 months.

Lagler:

We select bulls according to minimum standards for milk, cheese yield, and type. Obviously there are some cows where you might stress one criteria more and another less. We want to do some ET work to genetically improve our herds protein component in the milk.

We AI all heifers, spending about \$22-\$25 per straw. We get the best return for our AI dollar by spending more on the heifers to improve protein, udders, feet, legs, and capacity.

Describe your cow grouping system, including dry cows.

Houston:

Our milking cows are grouped into warm-up corrals, breeding corrals, and pregnant cow corrals. Fresh cows and hand milk cows are milked in a separate facility. Cows are milked 2X daily. Cows are pre-dipped and post-dipped. Fresh cows' udders are flamed before going on milk strings. Periodically we flame all cows udders as they leave the milk barn. Dry cows are grouped into far-off drys and close-up drys.

Lagler:

We milk three times a day. Our milk cows are divided into 3 herds and a hospital string. Each herd has its own separate rations. They are fed a Total Mixed Ration (TMR) 3 times a day, each followed by one or two feedings of alfalfa hay. The dry cows are divided into 3 groups. The just-dried cows are fed oat hay with a mineral supplement. The intermediate-dry cows are fed silage and 4# grain with a mineral supplement. The close-up cows are fed 10# milking ration and free choice oat hay. Currently we have heifers in with the intermediate dry group. We would like to keep the heifers separate and feed more roughage to the dry cows in the form of oat hay.

Most of our mastitis problems come from our freshening cows. We need to strengthen the care and feeding of our dry cows.

Do you employ a nutrition consultant?

Houston:

We work very closely with our nutritionist. During his visits, he and I visually look at all the cattle. He samples any feedstuffs that need to be analyzed. The same lab is used for all nutritional work.

Lagler:

We test our feeds and a feed consultant (Dr. Amos Zook of Loper Systems) helps us with our ration.

What is fed to the various cow groups? How do you monitor the amounts being fed to each group?

Houston:

We have rations designed for far-off drys, close-up drys, fresh cows, warm-ups, breeding and pregnant categories. Oat hay is fed to the dry cows every other day with a mixture of alfalfa hay, corn silage and cotton burrs. High phosphorus mineral and salt are fed to the dry cows free choice. Ingredient composition of the rations are shown in the table.

The close-ups are fed 10 pounds per cow of the dairy cow mix in addition to their roughage. Fresh cows are fed 30 lbs. of the dairy mix. Warm-up cows are fed 39 lbs. of the dairy mix. The cows stay in the warm-up corrals for 30 to 45 days. The breeding group is fed 46 lbs. of the dairy mix. The protein level is 16.74% and the crude fiber is 14.5%, both on a 90% dry matter basis. Their present total consumption is 64 lbs. Pregnant cows are fed 39 lbs. of the dairy mix. Total consumption is 55 lbs. per cow.

We have a ration program on our computer. Corral numbers are updated every day and a new ration is printed for the feeder. We monitor feed inventories very closely. As you know, cows are creatures of habit so we try to feed them similar ingredients every day at the same time.

Ingredient Composition Of Price's Roswell Rations

ingredients	dairy cow mix	warm-up ration	highs ration	preg. ration
C/S meal sol	3.50			
whole cottonseed	6.50			
distillers grain	2.75			
beet pulp	3.75			
grain screen pellet	1.00			
hominy	4.00			
blood meal mix	4.00			
mineral mix	1.70			
alkaten	.30			
cotton burrs	2.00			
41CP-1P molasses	1.00			
corn silage	14.00	10.00	10.00	10.00
alfalfa hay blend	4.00	2.00	4.00	4.00
oat hay	1.00			
dairy cow mix		39.00	49.50	39.00
alfalfa haylage		13.50	14.00	13.50
50% corn-50% milo		13.00	13.00	13.00
TOTAL	49.50	77.50	90.50	79.50
lbs. air dry intake	39.08	53.04	63.51	55.04
lbs. grain/cow/day	28.35	35.34	41.35	35.34
cost (\$/cow/day)	\$2.90	\$3.62	\$4.36	\$3.74

At present, we are not feeding a total mixed ration (TMR). Alfalfa hay is fed one hour before the grain-silage mix in the mornings at 6 AM. The grain-silage mix is fed at 7 AM, 3 PM, 8 PM and 2 AM. Our feeder puts out the mixed feed at 7 AM and 3 PM, and loads the two night loads. The barn foreman does the feeding at night. Thirteen pounds of rolled corn and rolled milo on a 50- 50 basis are fed in the barn during the milking process.

Separate loads of alfalfa haylage, corn silage and alfalfa hay are fed at regular intervals during the day. The ration is pushed up to the mangers every six hours. Oat hay is fed to dry cows every other day. This works well in our feeding logistics.

Protein feeds currently used are cottonseed meal, dried distiller's grain and a blood meal, animal fat premix with hominy or wheat midds as a carrier for easier handling capabilities. Our molasses mix is a 41-1 mix. We feed six pounds of whole cottonseed per day to the milk cows. I usually feed milo hominy instead of corn hominy because of the price spread. Other commodities used are cottonseed burrs, beet

pulp, bufferite, and calcium. Heifer mineral with monensin is fed to heifers from three months through 17 months. It is very difficult to get enough fiber in a high energy milk cow ration.

Lagler:

Dry matter intake is the key to high production. We constantly strive to improve the quality of home grown roughages. We intend to try mixing alfalfa with grasses instead of clovers to achieve high protein and tonnages in later cuttings. Our Total Mixed Ration is based on home grown silage. Besides ground corn, we use a lot of by products: whole cotton seed, bakery waste, beet pulp pellets, canola or soybean meal (soy is more dense, but also more \$\$), mill run (source of phosphorous), and a vitamin and mineral package. A typical ration for the high cow herd in "as-fed pounds" would be:

- 5# whole cottonseed
- 5# canola
- 7# ground corn
- 3# bakery waste
- 6# beet pulp pellets
- 3.75# wheat mill run
- 1.5# soybean meal
- 7# liquid brewers yeast
- 1.33# lactating mineral and sodium bicarbonate
- 18.66# grass silage
- 25# corn silage
- 16.25# alfalfa hay in the mix
- 4# loose hay in addition to the TMR

We add liquid yeast to the total ration to keep the moisture at 50%. When the mix is wet, we back out the liquid yeast.

Total cost per day of high cow ration is \$4.20/cow/day giving and average of 101# of milk. The whole milking herd cost is \$3.60/cow/day currently averaging 84# of milk or \$4.29 per CWT of milk.

Do you grow or buy your forages?
What quality standards do you
require for your forages?

Houston:

The alfalfa hay fed to the milk cows is generally purchased locally from three producers. Each producer's hay is stacked in barns and kept separate from the other producer's hay. I try to purchase alfalfa hay that is 21% protein on a 100% dry matter basis. The acid detergent fiber should be 31% or less. I want the stems to be soft and the hay to be free of foreign material and bright green in color. Moisture content of 13 to 18 % is necessary for storage.

We grow our own alfalfa haylage. It is cut at very early bloom. It is stored in a pit, inoculated, packed properly and covered with 6 ml plastic. Our average shrinkage is 8%.

Corn silage is contracted from local farmers. We insist on grain varieties of corn that will produce high quality roughage. The farmers are paid on a sliding scale with 72% moisture being the base.

Lagler:

We purchase all the alfalfa hay we feed the milking cows from eastern WA and OR. We test the hay for moisture, protein, acid detergent fiber, neutral detergent fiber and lignin. On a dry matter basis, we want 22% protein, 25- 28% ADF, below 40% NDF, and below 5% lignin. We strive for high intake, high density (not hot) and high digestibility.

We raise orchard grass on the land we spread heavily with liquid manure. On the land we graze and chop for silage, we plant annual and perennial tetraploid rye grasses with white clovers. We receive an average of 44" rainfall in our area. Because of our climate, we have gone to the Ag Bag system for silage storage. This way we are able to harvest the crop when weather permits and the crop is in early maturity. The first two cuttings are for silage. On the irrigated land we make two more cuttings into hay, on the dry ground we get one cutting of hay. Cutting the grasses for hay and silage at the correct maturity is one of the most important management practices we try to follow.

The years when we make good quality silage, it is much easier to get high milk production and be profitable. The bagging system also allows us to keep our higher quality feed for the milk cows and divert

high fiber feed to the heifers. Feed must be fertilized correctly, be free of weeds and cut at correct maturity for highest nutrient quality and digestibility.

Do you have any final comments:

Houston:

Our motto is, "Our cows are not contented. They are striving to do better."

Lagler:

Our overall goal is high production at economical feed cost based on home grown forages. Keep milk quality up and protein up in milk so we continue to receive the highest price for our milk.

At the present time, our co-op pays a premium and they do not want milk from BST-treated cows. When given the OK by our co-op, we would consider using BST on the DNB and tail-enders as a management tool.

notes

Feeding To Make Money: Managing Nutrients In The Total Herd

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Feeding to make money takes on many shapes. We can spend a lot of time talking about least cost or maximum profit ration formulation, feed purchasing and growing strategies. We can discuss the strategies in feeding the various groups of animals on the farm. We can make quantitative points about the importance of analyzing feeds. We can discuss the optimum strategies for manure management. Outlines can be made of the daily feeding management strategies. Each of these are important and a significant amount could be written about each of them. The goal is to make a good return on investment. In order to accomplish this it is necessary that we integrate each of these areas into a system. It is the system approach that we will use in our discussion in this paper.

Too frequently on farms we spend excessive time on the area that we feel most comfortable with or like most. Some of us would rather spend time with the milking cows, others with the replacements and still others with the crops. The truth is we need to spend enough time on each of the areas in order to make the area profitable.

I think that it is important that you divide your feeding system into profit areas. I would suggest some of the following divisions; you may have more:

- Feed Procurement
- Manure management
- Animal grouping and flow
- Ration formulation
- Feeding management

These divisions represent areas that can have a significant impact on cash flow and profitability. This list does not include labor management; it is implicit and the costs are real. It is essential that you understand that each of these areas are not isolated, but are interdependent. It is this last point that many times is not considered when making management decisions. This can become exceedingly painful when capitol expenditures are involved.

Feed Procurement

When we discuss feed procurement we need to now consider nutrient flow on the farm and nutri-

ent balance on the farm. It is this latter point that prompted me to place manure management in second position. We need to carefully integrate our nutrient input on the farm with the nutrients leaving the farm. A price needs to be placed on the removal of N, P and K from the farm in a form other than milk and animal.

Growing crops needs to be considered as a feed procurement activity. If this is a part of the feed operation you need to ask whether it is making you money. Can you buy the quality forages/grains for less money than it costs you to grow them? If you can, will the quality be as consistent as that which you can produce? If you are to purchase forages what will this do to your farm nutrient balance? If the decision is to produce forages/feeds on your farm then how can you produce them most profitably? You should know exactly what your per-acre costs are, including costs such as taxes, machinery depreciation, storage costs and depreciation, inventory shrinkage, and nutrient variability from year to year. Finally, it is important to know what your real yields are per acre. This means weighing the crops as they come off the fields, and it is suggested that scales be installed. This means knowing the exact acreage that you are growing your crops on. Many of us do not have exact measurement of the acreages that are being cropped.

I can't overemphasize the importance of quality forage for optimum performance in your herd. Quality has many facets. The most obvious one is the nutrient content of the forage. It is critical that the appropriate forage with the correct nutrient content be available for all cattle at all times. This means routine analysis of the feeds. The most important routine analysis is the moisture level of the ensiled or wet feeds, if they are to be used in a TMR. In Finland and the U.K. they also measure the digestible dry matter, using enzymes. This practice is also used in Japan. This allows them to feed more forage than we do. We have not adopted the approach yet, partly because we are using legumes and have found that using enzymes to predict the energy values of forages is not accurate enough. We need to

put much emphasis on this in the future if we are going to increase profitability. It is important that we measure the protein and carbohydrate fractions. Equally important are the macro and trace elements. We need to know more about the availability of the minerals in the feeds to the rumen and to the cow.

The feed storage system needs to be designed so that it will be possible to access quality forages at all times. The system needs to be arranged so that the time to feed is minimized and accuracy will be assured. Quality also means that the particle size is correct, the acid or NH_3 levels are not excessive in the silages. If the milk is to be used primarily for manufacture of soft cheeses then clostridial spore contamination of the silage becomes a concern. Feeds need to be free from molds and yeasts. Aerobic stability is of great importance for silages and the amount fed out each day needs to be adequate to ensure fresh feed.

The purchase of feeds takes on several dimensions. First, the feeds should be purchased based on economic considerations. These economic considerations are the following:

- Price
- Variability of price
- Availability of feedstuff
- Variability of nutrients

The other considerations are quantities that you need to purchase to get a good price and the inventory turnover. It may not be wise to buy a quantity of an ingredient that will turn over slowly, especially if that ingredient has a poor shelf life. Remember, this is money that is tied up for a period of time that may be uneconomical when compared to buying it as a percent of a supplement that will turn over more frequently.

It has been my personal observation on many farms that there are inventories of minerals/vitamins and other feed additives on the farm that do not meet the needs of the herd and out of date. Careful planning is needed to control these inventories.

Manure Management

Nutrient balance is becoming an important consideration in the purchase of feeds. If you are pur-

chasing excess amounts of N, P and K from feeds that cause nutrient balance problems on your farm then you need to reconsider the purchase of that feed. For example, the latest problem is with K. We are finding that high-K rations is the primary cause of milk fever. We are, with manure lagoons being highly efficient at recovering the K excreted by the cow in the urine. This is being spread on the fields and the forage plants are taking up the K in luxury consumption. It is becoming a challenge to balance against high K forages. Anionic salts have helped. However, the long term solution is to reduce the amount of K that we bring on the farm.

Feeding excess N is not only wasteful, but it will also have a negative effect on animal performance, particularly reproductive performance. In hot areas, especially where humidity is a problem, excess N intake can increase the animal's heat production and also water intake. This will cause a change in the animal's intake behavior and lead to metabolic upset. This problem can be compounded if water intake is restricted in any way. It will not be long before there will be an additional cost that will need to be input into our ration programs to economically assess the cost of manure disposal.

Grouping

The concept in the grouping of animals is to create groups that are as uniform as possible in size, age, productivity and stage of lactation and/or gestation. This is advantageous from a nutritional point of view. It is also will reduce the feed costs per animal per day. For example, if we are feeding one lactation group we will feed for the high producing animals in the group, i.e. the cows between freshening and peak. We are overfeeding the cows in mid to late lactation. Another advantage to grouping is being able to feed special supplements that are high cost for short periods of time. This is especially important during the last 3 weeks before calving and the first 4 weeks after calving.

Grouping should be a dynamic process. The system should be designed to minimize labor and to maximize taking advantage of the physiological state of the animal. For example, we need to espe-

cially focus on the replacement between weaning and puberty, the late gestation cow in the last 3 weeks before calving, and the fresh cow. There is an optimum blend, depending on things such as herd size, holding area and parlor size, calvings per week, distribution of lactation numbers for the weekly calvings, and season of the year.

Animal numbers in a pen/string need to be governed by feed/water bunk space and resting space. The rations that are formulated for the group will depend on the lactation number or age, body weight, days in milk, milk volume and composition and daily gain. Factors such as temperature in the pen need to be considered when formulating the diet. It is important to realize that the ration for a designated pen can change frequently depending on the composition of the pen.

The herd, contrary to popular belief, also has replacements and dry cows. Further, the replacements are not a homogeneous group but at least 6 groups with distinct differences in nutrient requirements. The dry cows, defined here as those animals that have gone through one lactation or more, have at least 2 groups and some would argue 3 or 4. If we think of the different groups of animals on the farm not as physical groups in the sense of pens or strings, but as physiological groups with unique nutrient, behavioral and management requirements, then we can better physically group the animals and formulate rations for them that will maximize performance, at high efficiency and at maximum returns. We need to first define the physiological groups on the farm and then provide some guidelines for the management of the groups so that we can better feed the herd. Below are

defined the different physiological groups on the farm.

Please understand that physiological and physical groups do not necessarily equate. You will, in all probability, have less groups. However you need to, for ration formulation purposes, adjust your rations to accommodate the differences in intake and requirements for the different groups physiological groups that you put together. The obvious one being putting springing heifers in with the dry cow groups. They have a growth requirement and eat less.

Ration Formulation

Most nutritional consultants today are using a least cost ration program. If you are buying supplements from a feed manufacturer they usually will be using a least cost program to formulate rations. There are a number of least cost programs available to producers that are good programs. There is only one maximum profit program that is available on the market. This is based on the original program developed at the University of California and is now available through Tri Logic.

I am most familiar with Spartan, a program developed at Michigan State University, and the University of Pennsylvania version of the Cornell Net Carbohydrate Amino Acid model, both of which have LPs in them. I will restrict my comments about formulation to those two programs.

I like to use a LP in the formulation of rations for farms. It forces me to be more logical. We need to ask many questions about the herd, groups of cattle, feed inventory, the environmental restrictions and the any labor restrictions that may be imposed (i.e. feeding another time each day). Kaller and

Table 1	
Preweaned:	0-2 weeks 2 weeks to weaned
Weaned:	weaned to 4 weeks post-weaned 4 weeks to puberty puberty to breeding breeding
Bred:	early gestation mid-gestation
Late Gestation (helpers):	60-21 days pre-calving 21-0 days pre-calving
Late Gestation (1+ lactations):	60-14 days pre-calving 14-0 days pre-calving
Lactating:	fresh (0-28 DIM) reproductive (28-100 DIM) mid (100-200 DIM) late (200 DIM to dry) first calf

Skidmore developed, with support from Elanco, a Expert System model called DAIRYPERT. This model was discussed in a Cornell Agricultural Economics publication in 1991. The model was to have been released by Elanco for use in the field in relation to the management of herds receiving bST. It never was released. I was disappointed because it represented a significant step forward in identifying problems on the farm. The model asked the producer many questions about the farm system. Much emphasis is placed on the physical facilities. Cow comfort and bunk space for feed and water are emphasized. If these are inadequate the program will warn the user of a problem. For example, if the feed bunk space is restricted to less than 2' per cow, it is warm, there is secondary fermentation in the forages, the facilities are poorly ventilated and the producer feeds once per day, there will be a warning given. The program will provide guidelines for change. The change could involve feeding management, change in ingredients (the Cornell model is built into the model to assess the interaction of the environment and the ration) fed and/or facilities. This is a systems approach to ration management. This is the approach that we need to take in the future. For now the LP allows me to make these type of decisions in an organized manner.

Will Hoover, West Virginia, has placed much emphasis on carbohydrate nutrition. This emphasis is correct. The dairy animal is a ruminant. We must formulate rations to maximize rumen function. This makes sense from an economic viewpoint and in terms of nutrient management. Hoover's group has developed a fermentable carbohydrate system. He has conducted research that demonstrates the value of highly fermentable fiber in feeds. He calls this the fill

system. Rapidly digested fiber will reduce the fill effect of the fiber more quickly allowing the cow to eat more. This concept is supported by the work of Allen of Michigan State University who has determined that there can be large differences in the digestibility of fiber of different corn silage varieties.

The second component of the carbohydrate system is the non fiber carbohydrate(NFC). This is a calculated number that represents the sugars, starches VFA, pectins and glucans. The sugars and starches are the major components that have the greatest impact on rumen function. Hoover has developed a large data base on the sugar/starch content of feedstuffs. He has also measured the fermentability of the sugars/starches in the rumen. From this he has developed some preliminary recommendations for feeding the early lactation cow. He does not use the net energy system. He feels that the cattle will perform if we balance the carbohydrate and protein fractions. I would go one step further in the formulation. I think that many times because of feed inventory and environmental considerations we do not have the right combination of fermentable ingredients. We can include fat as a energy source. This is a good management tool.

I have been using Spartan to do routine balancing of these components. Spartan has a column for starch and fermentable starch. There are 4 columns

Table 2. Nutrient constraints

NUTRIENT	CONSTANT	MINIMUM	MAXIMUM
Dry Matter			
eNDF			
Fermentable Fiber			
Starch			
Fermentable Starch			
NEI			
Total Protein			
Soluble			
Degradable			
Undegradable			
Bypass Lysine			
Bypass Methionine			

that can be added and I have added fermentable fiber as one of them. In Tables 2 and 3 can be found examples of the approach used in formulating with an LP. In Table 2 we define the nutrient requirements with modifications for the environment that surrounds the group.

In Table 3 we can constrain the feeds as defined by feed inventory or quality constraints. Placing a price on the feed, either what it costs delivered or what it costs to produce it.

There have been many consultants who have adopted this concept on carbohydrates and proteins and I believe are well satisfied. There are many people now using the Net Carbohydrate model. The

of lipids that we feed to dairy cows. Too much unsaturated fat from vegetable sources has a negative effect on rumen function. This is especially true if the cow eats a significant amount of the unsaturated fat at once. A mixture of saturated and unsaturated fats is best. If rumen bypass fats are being fed it is important to know the digestibility of the fat. It appears that some fats that are high in Stearic fatty acid have a lower digestibility in the small intestine.

Since the publication of the dairy NRC, formulating for protein fractions has become pretty well accepted. The major flaw in the system is still a lack of a good laboratory analysis system that is acceptable to everyone. In the Northeast we have been

measuring protein solubility and acid detergent insoluble protein for many years. We feel that this gives us an estimate of the rapidly rumen degraded protein and the unavailable protein. We have been using the S. Griseus enzyme to measure degradability or measuring the protein insoluble in neutral detergent

Table 3. Feed constraints

FEED	CONSTANT	MINIMUM	MAXIMUM
Alfalfa hay			
Corn silage			
Barley			
Corn			
Soy 48			
Bypass Prot. Suppl			
Min/Vit			

above concepts are in the model in a more sophisticated form. I have found that I can use the concepts that are in DAIRYPERT on environment and management analysis to help me set the minimum and maximums on starch and fiber fermentability to formulate rations that perform. We need much more work on this. At this point I would be working closely with your nutritionist to evaluate the rations for these carbohydrate and protein fractions.

The use of lipids in rations has now become an excellent management tool. For high producing herds it is recognized, given the variable environment that surrounds the cows and the variability of our forage quality (fiber digestibility being the major one) and grain quality, that we often need a high energy source that is consistent. Lipids provide that source of energy. We need to be careful in the type

combined with rates of digestion to measure the bypass(Cornell Model). We need to reach agreement on methods. We have been reasonably satisfied with the above methods.

Ration formulation for the degradable and soluble protein is extremely important for all groups of animals on the farm. If these are balanced properly the carbohydrate fermentability will be enhanced. The work of Hoover and field experience strongly argues for providing part of the degradable protein from solvent extracted soy. This provides the peptides and rumen degradable amino acids needed to enhance starch and fiber digestion.

Once the rumen is optimized then it is necessary to provide a quality bypass protein. It is suggested that a combination of corn gluten meal, blood meal and a little fish meal makes an excellent supplement.

This will provide the right amount of methionine, lysine, isoleucine and possibly arginine needed for optimum production. Our recent research has emphasized the importance of amino acid nutrition for the dry cow and fresh cow. Research is suggesting that we need to pay attention to the protein quality for the replacement from birth through at least puberty. After this the replacement should be able to obtain enough amino acid from microbial flow to the small intestine.

Mineral and vitamin nutrition of the dairy animal can be the most important part of the nutrition program. It is often forgotten or we make sure that the Ca and P are adequate and do not look much further. In fact we need to constantly monitor the mineral and vitamin nutrition of the total herd. The requirements are significantly different among the different groups of dairy animals on the farm. We need to pay particular attention to the trace minerals and vitamins. It is easy to assume that the balances are correct but frequently the balances change with changes in the forages.

Water is frequently overlooked. The water needs to be moderate in its mineral content. Data would suggest that the pH of the water should be near 7.0. If the water is over 8.0 or below 6.0, there can be an intake problem. Bacterial contamination, especially coliform, should be minimal or non-existent. The water should be free of organic matter contamination. This means that the water tanks need to be cleaned frequently. We use tip-type waterers that are on a pivot. These are very easy to dump and clean. Waterers are an excellent place for stray voltage. This needs to be checked carefully by someone skilled in the area. The available space for cattle to drink is a function of productivity level and environmental temperature. In too many barns there is inadequate "bunk" space for cows to drink. I saw at a farm in Alberta, Canada where there was a flowing water trough for each side of the parlor. I was in a parallel parlor in Japan where there was a water trough on the front of the stalls in the parlor. Both of these producers were very satisfied with the results.

Feeding Management

We can balance the most sophisticated rations in the world with the most sophisticated grouping system and the animals will not perform. How we feed what we have formulated is the difference between success and failure in making money from feeding your herd. You need to have some monitoring tools in place. Historically, the use of DHI has been a tremendous tool for management. Today it still is an excellent tool. However, due to herd size and the dollars involved we need more frequent measurements. The use of electronic milk measurement, cow ID and microcomputers have provided us with some excellent additional tools. In addition we need to use keen observation on dry matter intake amounts and change, body condition score and change, manure condition score and change, and change in milk volume and composition over the lactation. With this management information you will be able to make intelligent changes in rations and daily feeding strategies.

There are some additional measurements that might be helpful in the future. In Sweden and Finland they have been using milk urea and milk acetone as a routine management tool. The combination of these two measurements provide information on the cow's efficiency in the use of protein and energy status. The concept of measuring "signature" metabolites in milk is not new. We discussed this several years ago with people from Kodak. If unique metabolic products of metabolism can be identified in milk and measured cowside and/or through DHI, it can help in making management decisions. To date in addition to milk fat and protein we have available the potential of acetone, progesterone, urea, non protein nitrogen (urea is a part of) and citric acid. We do not know much about citric acid. This information is available when the milk ureas are run on the latest instrumentation from Foss Electric. Research needs to be done in this area.

We need to apply the principles discussed above to the whole herd. We need to start with the replacements. We need to plan on replacements calving at 21-23 months of age at 80-85% of mature frame size. This will result in a significant percentage of the first calf heifers peaking over 100 lbs. of milk if

they are Holsteins. This, in reality, becomes the most important part of your nutrition program in the herd. This will result in you also able to feed a higher proportion of forage to the total herd, which increase your profitability. In that you will be able to assess the quality of the animals in the first lactation you will be able to cull more intelligently on production. The late gestation animal or dry cow nutrition needs intensive management. All of the feeds need to be analyzed for these groups. You will need high quality bypass protein supplements and you will need to balance the minerals and vitamins carefully. The key is to make absolutely sure that what you are balancing for they are eating. Feeding hay on the side will not work. Chop it and incorporate it into the ration. We are also finding that we need to balance the ration protein for 13-15% C.P. with 25-28% of the protein being soluble for the close-up dry group. The first 4 weeks post partum is critical. The cows

are not eating at capacity so there is a need for a high ration density with a carefully balanced carbohydrate mix.

Good feeding and environmental management is a must during this period. If the cows are sharp and aggressive after the first 4 weeks then the rest of the lactation will fall in place.

Summary

Feeding the high producing herd needs a total integrated approach. If you do not want to do this yourself then identify a nutritionist that is willing to look at the total picture. Have the nutritionist sit down with your veterinarian, crops specialist (If you are growing forages) and key herd people to discuss the total herd nutrition program. Identify the weak links and prioritize the short term and long term goals for the herd. You will find that the return over feed costs will begin to improve.

notes

Management Strategies For TMR Feeding Systems

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During the last 3 decades, average herd size of U.S. dairy farms has increased. Over the same period of time, production per cow and level of concentrates fed per day have also increased. In 1969, A.H. Rakes suggested these changes were increasing the need for specialization and automation of the feeding system, and as a result of these changes, new feeding systems have been developed. Coppock and coauthors, in 1981, reviewed the ongoing shift from feeding individual ingredients in multiple locations to feeding complete rations. The reasons for these changes were the same as those discussed by Rakes. As dairy farm managers adopt, adapt, and manage total mixed rations, there are several key points that can influence the success of the feeding system in meeting the goals of the nutrition management program. The focus of this paper is the evaluation of critical decisions or control points in successfully managing total mixed ration (TMR) feeding systems.

Grouping Decisions

Grouping decision is the first decision in managing the TMR system. Simply put, which cows are assigned to which groups and what will these cows be fed? Some fixed factors such as lot size, stalls per lot, and size of milking parlor/holding pen will influence feeding group size. But how cows should be assigned to lots is an important management consideration.

Nutritional requirements, age, body condition, reproductive status, and health, have been and are used successfully on commercial farms to assign cows to groups (McCullough). Grouping by age for example, allows producers to limit social diversity and range of dominance within a group. Open (non-pregnant) cows in a single group can improve efficiency of reproductive management (i.e., estrus detection program focused on fewer groups). Some herds use separate groups to manage sick cows. By managing this group separately, managers reduce exposure of healthy cows to disease and allow cows treated with antibiotics to be milked last or in

a separate parlor. This management practice improves residue avoidance programs. However, the overwhelming conclusion of research in this area indicates grouping by nutritional requirements is the best basis for grouping cows into feeding groups.

The basis of any diet formulation is the accurate prediction of dry matter intake (DMI). Kertz and others summarized results of feeding trials conducted over a six year period. These researchers reported dry matter intake was better estimated if days in milk was included in the prediction equation. In addition, prediction of dry matter intake was most accurate if intake was predicted for each week from calving to 42 days in milk. After 42 days postpartum, predicted dry matter intake was improved if calculated for weeks 6 to 8, 9 to 13, and 14 to 20 of lactation. Another important observation was the difference in feed intake of first lactation cows compared to later lactation animals. These results define the importance of measuring and monitoring dry matter intake across groups. Therefore, TMR systems should be based on ration mixers equipped with

Table 1: The economic benefits of grouping strategies as influenced by level of milk production.

Grouping Strategy (lbs/cow/year)	Two Group Scenario		
	Level of Production per Cow (\$ per cow per year)		
	17,600	19,800	22,000
Nutrient Concentration	1,144	1,301	1,531
Nutr. Conc./NDF intake	1,144	1,304	1,538
Days in Milk	1,137	1,289	1,519
DHIA Test Day Milk	1,100	1,249	1,477
Test Day FCM	1,126	1,279	1,507

Grouping Strategy (lbs/cow/year)	Three Group Scenario		
	Level of Production per Cow (\$ per cow per year)		
	17,600	19,800	22,000
Nutrient Concentration	1,164	1,333	1,570
Nutr. Conc./NDF intake	1,166	1,338	1,579
Days in Milk	1,166	1,310	1,542
DHIA Test Day Milk	1,107	1,275	1,494
Test Day FCM	1,133	1,295	1,524

(Adapted from Williams and Oltenocu; J. Dairy Sci. 75:155 (1992).)

accurate scale. Accurate dry matter intake measurement should then be used to formulate group diets. This is critical in determining what nutrient density is necessary given the DMI. But, which cows go in which group?

Grouping Strategies

Several strategies have been proposed for production grouping of dairy cows. In a series of studies conducted at Virginia Tech, McGilliard and others evaluated different methods to group cows. Grouping criteria evaluated included CP percentage and Mcal net energy per lb expected dry matter intake (cluster) versus test day milk, fat corrected milk, (FCM) and FCM per unit metabolic body weight (defined as dairy merit). Over 100,000 test day records from 80 Virginia DHIA Holstein herds were used to allocate individual cows to groups. Cows were grouped into two groups per herd each month. Clustering cows grouped 25, 22, and 15% of cows in different groups compared to test day, FCM and dairy merit grouping strategies. Nutrient clustering decreased the variation within groups compared to other criteria evaluated. Schucker and others (1988) conducted a field study to investigate nutrient requirement grouping of dairy cows on commercial farms. Nutrient clustering of cows into feeding groups was found to be more accurate than test day milk production only.

Williams and Oltenacu, using a dairy herd production computer model, evaluated economics of grouping criteria. Several criteria for grouping were compared for a theoretical 100-cow herd with three levels of potential milk production per lactation (305 d; 17,600, 19,800, and 22,200 lb). These investigators reported required energy and crude protein per lb of predicted dry matter intake or per lb of estimated neutral detergent intake capacity supported highest milk production and highest income over feed cost per cow. (See Table 1).

Another decision that must be made is the grouping and movement of cows to and from feeding groups. Spahr and colleagues evaluated a grouping strategy program based on 3.5% FCM production as a percentage of body weight between 42 and 56

Table 2. Comparison of milk production and lead factors for cows by percent of cows in each group.

<u>% Cows per Group</u>	<u>High (Milk/LF)</u>	<u>Middle (Milk/LF)</u>	<u>Low (Milk/LF)</u>
100:0	45.3/1.3	.../....	.../....
50:50	56.3/1.17	.../....	34.1/1.22
33:33:33	61.4/1.14	44.7/1.08	30.6/1.21
25:50:25	64.2/1.12	44.7/1.13	28.2/1.20
50:25:25	56.8/1.17	40.0/1.07	28.2/1.20

(Adapted from Stallings and McGilliard; J. Dairy Sci. 67:902 (1984))

days postpartum. This method was most sensitive in identifying cows with low potential milk production. The authors reported difficulty in distinguishing between cows with medium or high potential. Results were improved by grouping primiparous cows separately from older cows. Potential problems with allocating cows to production group may be caused by early postpartum health problems (metabolic or mastitis) that would lower estimated potential. Body weight is also an important variable that would need to be included.

Lead Factors

Another critical point is movement of cows to different groups and how close the diets compare between groups. Spahr and others noted moving cows from high to medium TMR tended to reduce milk production but not FCM when grouping cows based on lactation potential. These results point out the importance of properly balancing TMR for the group being fed. Stallings and McGilliard evaluated methods of estimating lead factors for the formulation of TMRs for production groups. Their study indicated that as the group became more similar in milk production (less variation within the production group), the lead factor required was reduced. The results indicate that feed costs can be potentially reduced due to less overfeeding of low producers in the group. In addition, higher producing cows might better realize production potential. (See Table 2).

One-group TMR feeding has been used by dairy farm managers. Howard has described advantages and disadvantages of one group TMR. However, while one group TMR may have merits for small to

average size dairy operations, large operations can achieve obvious economic benefits by production grouping the herd. Advantages of grouping dairy cattle include:

- 1). More accurate ration formulation based on production,
- 2). With increased accuracy of ration formulation, production efficiency and profitability can be improved,
- 3). Special groups of cows can be better managed. For example, first lactation cows can be placed in groups with reduced competition by older, more dominant cows for feedbunk space.
- 4). Forages may be allocated and matched to production group based on quality of forage and level of production potential.

Feed Management

When discussing feed quality, forage quality is usually the topic discussed for dairy cattle diets. It is important, however, that all feeds be closely monitored for changes in nutrient composition. For TMR management, the discussion is better focused on factors that influence accuracy of the diet being mixed and delivered. One factor often overlooked but a major influencer of TMR management is dry matter content of ensiled forages. Workers at Penn State reported that increased uncertainty in forage DM affected the accuracy of protein and NDF of the TMR mix. Linn recommended ensiled and/or wet feeds (i.e., wet brewers grains) be monitored weekly to prevent large fluctuations in diets presented to cows in the bunk. Rainfall can also influence DM of ensiled forages being fed and the accuracy of diet mixing. Equal attention should be placed on monitoring DM of the TMR diet being offered in the bunk. Monitoring DM and amounts fed per group can be used to monitor dry matter intake (DMI) of groups. Dry matter intake is a critical component of the feeding systems management. Remember, if you don't measure it, you can't manage it.

In addition to the influence of DM of wet feeds on nutrient content of the mixed ration, dry matter of the total diet might influence DMI. Lahr and co-workers reported diets less than 50% dry matter may reduce feed intake by cows. However, Robinson

and colleagues reported no differences in DMI of diets ranging from 35-65% DM. These studies differed in how diet DM was manipulated. Lahr's study relied on replacement of alfalfa silage with alfalfa hay. In contrast, Robinson's experiment used concentrates and silages soaked in water. The optimal dry matter content of the TMR is the level that optimizes DMI by the herd. Close monitoring of dry matter is important in monitoring DMI by groups.

To measure DM, an on farm method that provides results accurately measured and easily attained. Oetzel et al. compared four methods of evaluating DM of feeds. The microwave proved most accurate but requires the most time and careful monitoring. The Koster Moisture Tester tended to over estimate DM of feeds but was comparable to microwaving. An electronic moisture tester was also evaluated and found to be comparable to the DM measurements made using the (time) and Koster Microwave oven (smelly house with unhappy spouse). While no system of measuring dry matter content of ingredients and mixed rations is perfect, it is important for farm management to be active in managing this important variable.

Forage Fiber Source Considerations

One goal of the TMR system is to limit "selective intake" of individual dietary ingredients. In traditional feeding systems, cows were fed concentrates separately from forages with dry hay and ensiled forages fed in multiple locations. As a result, cows had freedom to select and consume an unbalanced and/or unhealthy diet. The management goal of the TMR is to blend all dietary ingredients into a single diet including the effective fiber source. Historically, long, dry hay is fed as a free-choice supplement. Beauchemin and Buchanan-Smith reported the inclusion of long dry hay in the TMR increased milk production over 3 lbs per cow per day. In addition, cows consuming hay had meals of longer duration, and increased chews/minute during meals. Cows consuming long hay also spent more time ruminating and chewing. Increased chewing time tended to improve rumen pH by reducing time pH was below 6.0. While not statistically significant, this shift in rumen pH reflects better natural buffering of

Table 3: Effects of diet and feeding sequence on production and digestive function of lactating dairy cows.¹

Variable	Diet ²			Significance ³	
	C-S	H-C-S	C-S+H	Hay	M
DMI (lb/d)	36.1	36.6	37.1	.10	NS
CP (lb/d)	5.8	6.1	6.1	.01	NS
Milk (lb/d)	38.1	41.6	40.3	.01	NS
Milk efficiency					
Kg/milk/Mcal NE ₁	.58	.63	.60	.01	NS
Meal duration (min)	15.4	18.2	18.0	.04	NS
Rumination					
Periods per day	12.4	14.3	14.4	.05	NS
Chews per period	1306	1316	1350	NS	NS
Min/d	274	318	328	.05	NS
Min/kg DM	16.7	19.3	19.5	.05	NS
Boli per d	297	364	380	.05	NS
pH					
<6.0 (min)	280	213	214	NS	NS
Extent of alfalfa silage disappearance (%)					
DM	68.9	73.7	70.3	.05	.05
NDF	44.6	51.7	47.5	.05	NS

1: Adapted from Beauchemin and Buchanan-Smith (1990).

2: C-S = concentrate fed followed by silage. H-C-S = hay fed prior to concentrate followed by silage. C-S+H = concentrate followed by blended silage + hay.

3: Significance: H = Hay; M = method.

the rumen. This result would be expected to reduce off-feed problems and health problems (i.e., acidosis, laminitis). (See Table 3).

The incorporation and consumption of effective fiber benefits the cow by improving both production and health of the animal. Management considerations should include how the TMR mixer will handle long, dry hay; should hay be pre-processed to reduce particle size and improve mixing; is dry forage over-mixed which reduces dry hay to small, ineffective particle length. Linn pointed out that feeding 10 lbs of long, dry hay per cow per day supplies enough effective fiber to maintain normal, healthy rumen. When feeding processed forages (silage, processed hay, TMR mixer with hay processing ability), Linn recommended that 50% of ensiled forage particles be longer than .4 inches in length with 15% of the forage particles longer than 1.5 inches. It is important that forage particles consumed by the

cows have adequate length to stimulate rumen contractions and rumination. Over mixing of good quality dry hay can reduce particle size and result in inadequate effective fiber intake. Forages must be evaluated after mixing and delivery to the feedbunk.

Animals not consuming adequate amounts of effective fiber are at increased risk of metabolic disorders such as ruminal acidosis, laminitis, inverted milk fat to milk protein ratio and displaced abomasum. The management goal is to have cows consume adequate effective fiber to maintain health and production.

Feed Access And Feeding System

Availability of feed can often be a limiting factor in maximizing DMI. Some nutritionists use the term "slick-bunk syndrome" to describe feeding situations where cows are simply underfed and lick the bunk clean giving it a "slick" appearance. In most controlled investigations, feed access is measured as the time cows have physical access to adequate amounts of feed. Freer et al. (1962) observed an interaction of forage quality, feed access, and DMI. These results indicate intake is influenced by forage quality and should be considered. This difference would be especially noticeable if cattle were grouped and fed different quality forages across groups.

More applicable to well managed farms, access to ad lib amounts of high quality feeds should be considered. Erdman et al. (1989) reported increasing feed access time from 8 h to 20 h per day increased feed intake from 51.7 lb/d to 54.3 lb/d in mid-lactation cows. Increased access did not change milk production and intake, as a % of body

Table 4: Interaction of access to feed and forage quality on DMI and chewing activity¹.

feed	access (h)	DMI (lb)	-----time (min)-----		
			eating	ruminating	resting
Hay	24	29.6	405	565	470
	4.5	25.3	261	534	645
	2.0	17.9	122	434	884
Straw	24	13.8	343	474	623
	4.5	11.2	251	392	797
	2.0	8.5	121	358	961

¹: Adapted from Freer et al. (1962).

weight, was not changed. Cows with increased feed access time did have higher weight gains (8h/d, +.8 lb/d; 20h/d, +1.5 lb/d). In contrast, Martinsson and Burstedt (1990) measured intake and production responses of early lactation cows given different access to feed (8h to 24h). In this study, diet ingredients (hay, silage, and concentrates) were fed separately. Cows assigned 8h feed access time were fed 0600 to 0930 and 1230 to 1700h each day. Cows with restricted feed intakes in year 1 tended to have reduced feed intake (8h DMI = 30.4 lb/d vs 24h DMI = 32.6 lb/d). Intake differences due to feed access were greater during year 2 (8h DMI = 32.2 lb/d vs 2h DMI = 35.4). The large difference in DMI resulted in a 2.4 lb increase in milk production. These workers suggested feed access is important especially for early lactation cows.

Feed access and intake can also be influenced by competition for feed and feeding space (Albright, 1993). Friend and Polan (1974) reported cows spent almost 5 h/d at the feedbunk. The social rank of animals within the group influenced time spent at the bunk after feed was placed in the bunk. Therefore, more dominant animals had more opportunity to consume feed first after feeding. Subsequent research reports showed .7 ft per cow would allow adequate access and not depress intake (Friend et al., 1976). Most current recommendations establish feeding space per cow at 1.5 to 2 ft per head. These recommendations agree with results of feeding behavior research trials. A more recent report indicated that cows selected feeding positions in fence-line feeders based on dominance relationships

(Manson and Appleby, 1990). Cows with the greatest differences in social dominance had average separation of 4.4 feeding positions (feed position = 2 ft per position). Albright (1993) reported cows fed total mixed rations in fence-line feeders ate longer than cows fed in bunks with access around the entire bunk. Feeding system design and layout can potentially impact intake by influencing feed access time via manipulation of animal to animal interactions.

Feed Palatability

One critical aspect that must be considered on the feed side of feedbunk managements palatability of the diet. For example, two reports from the University of Maryland described the effects of silage pH on feed intake. Shaver et al. (1984) predicted optimum silage organic matter intake would be achieved with a forage pH equal to 5.6, with an optimal range between pH 5 to 6. Erdman (1988) reported partial neutralization of corn silage (from pH = 3.64 to pH = 5.44) increased forage DMI 2.2 lb/d. Total DMI was also increased (2.9 lb/d). Corn silage pH was manipulated by the addition of sodium bicarbonate. Milk yield was not different, but milk fat % and 4% FCM yield were increased by buffering corn silage. Palatability of forage may also explain differences in intake of alfalfa hay and straw reported by Freer et al. (1962).

Concentrate palatability can also influence intake. Dustiness and texture of concentrate mix can depress intake of grain mixes. Feed additives have been found to depress grain intake. The recent development of cation:anion balancing and use of anionic salts can influence concentrate consumption. Oetzel and Barmore (1993) ranked anionic salt mixtures based on intake and reported MgSO₄ was consumed better than other anionic salts. Animal by-product feeds (animal proteins and fats) have been reported to decrease intake. In most cases, feed intake returned to normal following an adaptation period. Inclusion of new feeds (new silo, hay cutting, etc.) and feed additives in the diet should be

done gradually over an adaptation period. This strategy helps prevent potential off-feed problems and better maintains animal performance.

Water Accessibility

Water consumption has also been found to influence DMI and milk production. Dado and Allen (1994) reported a highly significant correlation between water intake and milk yield (Pearson correlation coefficient $r = .94$). A significant relationship was also described between DMI and water intake (Pearson correlation coefficient $r = .96$). Drinking time required 10% of time spent eating (Table 5). While eating events required more time, cows had more drinking bouts (14.0, all lactations) than eating bouts (11.0, all lactations). These differences indicate the importance of animals access to water. Time spent drinking was not described relative to eating activities during the day. However, water supply should be convenient to feed to stimulate DMI. A general guide is to provide water within 50 ft of the feedbunk.

Feeding Management Considerations

Robinson (1989) described potential interactions between feeding strategies, feedstuff characteristics, and quality of animal management. Options and possibilities are unlimited for consideration of feeding systems and strategies within a given animal facility. Within a feeding system, many factors influence DMI. Diet formulation, mixing, and feeding to ensure normal rumen function is a high priority for achieving maximum intake and productivity. Control of diet ingredient intake is also a primary goal of the feeding management system. Feed access contributes to animal performance and success of the feeding program. Palatability of feed can stimulate or depress intake. Blending and use of feed ingredients with poor palatability should be done carefully to minimize off-feed problems. Maintaining fresh feed during periods of high eating activity (ie. after milking) stimulates larger meal sizes as a result of improved palatability. Water supply must also be fresh, clean and accessible to maintain intake and production. Feeding management strategies are dynamic to feeding system, diet, and farm-

Table 5: Milk production and feeding behavior statistics of lactating Holstein cows¹.

Item	Primiparous Mean	Multiparous Mean
Milk (lb/d)	63.1	82.5
DMI (lb/d)	44.0	54.6
Time eating (min/d)	284	314
Water intake (L)	63.2	89.5
Time drinking (min/d)	17.7	19.1

¹: Adapted from Dado and Allen (1994).

stead layout (NRAES - 38, 1990). Manage all factors that influence DMI to achieve and maintain high intakes and animal performance.

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Minimizing Transitional Stress For Close-up Dry Cows

Field Experiences and Applications

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Transitional stress in cows going from the close-up dry cow period into early lactation can have a tremendous impact on their subsequent lactation. The primary transition period for cows comprises the last 21 days prior to calving through the first 21 days after calving. Obviously, minimizing problems at calving is one way to reduce transitional stress in cows. However, our single most important goal in attempting to minimize transitional stress should be to freshen cows with excellent appetites. When we can get fresh cows eating well immediately after calving, everything else is much easier.

Feeding programs for cows during the transition period need not be complex or changed frequently. The challenge is to avoid freshening problems and to get cows eating as much as possible as soon as possible. How we manage cows during these critical six weeks of the transition period, to a very large extent, determines a cow's health, reproductive performance, milk production and profitability for the entire lactation.

Transition Period Feeding Strategies

Various approaches to feeding the transition cow exist in our industry. Some of these approaches work better than others, but overall we have found that simplicity on our behalf and close attention to cows by the producer is always the best general approach. Although some of the current concepts and technologies used in feeding the transition cow can be extremely effective and beneficial, if the producer becomes confused or gets caught up in trying to micro-manage too many details, success may be short-lived.

We have experimented with many types of feed-stuffs, additives, ration manipulations, management strategies, etc. Through personal experience we have gained the most success with the use of the following:

- Anionic salts (when used properly) accompanied with elevated levels of both calcium and magnesium.
- Direct-fed microbials (when scrutinized closely for concentration of colony forming units or CFU's, host specificity, types of bacteria present, and cost).

- Niacin (at 6-12 grams per day) to help prevent ketosis, increase microbial protein synthesis, and increase blood glucose levels.

- Bypass protein to balance protein requirements and to assist in intake of bypass protein sources post-calving.

- Adequate effective fiber from long-stemmed forage (minimum of 8-12 lbs. per day).

- Similar ingredients as contained in the fresh cow ration to minimize ruminal adaptation time.

- Heavily fortified vitamin and mineral levels.

Although anionic salts (anions) were used initially to control milk fever in problem herds, we have found their use to be beneficial in other areas as well, such as reduction in retained placenta, improved feed intake immediately after calving, and enhanced start-up milk production. Various sources of anions are available, but we have experienced the most success with calcium sulfate, magnesium chloride, calcium chloride, and magnesium sulfate. A more pronounced palatability problem has been observed with the use of ammonium chloride and ammonium sulfate, and we also have more difficulty balancing rumen bypass protein needs in close-up dry cows when using the ammonium salts.

We will typically use from .25-.75 lb. of anions in most rations to attain a DCAD (dietary cation-anion difference) of -10 to 0 milliequivalents per 100 grams of diet dry matter. Our results with anions have also been much better when combined with 150-200 grams of calcium and 40-60 grams of magnesium in the daily ration.

The single most important lesson we have learned from the use of anions is that this concept of feeding close-up dry cows is certainly not for everybody. We recommend the use of anions only in very well-managed herds under the following criteria:

1. All forages will be analyzed for mineral content.
2. Changes in forages fed to close-up cows will be minimal.
3. Cows will receive the anions for a minimum of 10 days and a maximum of 30 days.
4. Cows will not be pastured during the close-up period.

5. The nutritionist will be notified of any deviations from the above criteria in a timely manner.

The use of direct-fed microbials (DFMs) has increased over the past few years but many questions remain concerning their use. We have found that the transition cow is a good candidate for the use of DFMs due to the stress from pre-freshening to freshening, and the subsequent limitations on feed intake during this time. To replenish depleted gut microflora we recommend that our herds use a highly concentrated, bovine-specific DFM containing viable lactobacillus acidophilus and streptococcus faecium bacteria. Best results have occurred by inoculating cows approximately 21 days prior to calving, feeding the DFM daily during the close-up period, and inoculating fresh cows on days 0, 3 and 7 post-calving combined with feeding the DFM daily during the initial 21 days after freshening.

Use of DFMs after the transition period depends upon level of production, type of feeding program, environmental conditions, and overall cost effectiveness in the ration. We have observed obvious benefits from the use of DFMs including increased feed consumption before and after calving, increased start-up milk production, and reduced incidence of bloat and acidosis. Hopefully, more research with DFMs will be done in the future to determine optimum conditions for their use; why responses in the past have been somewhat inconsistent; which bacteria are most important in a variety of feeding programs; and what levels of bacteria are required for maximum benefit.

The B-vitamin niacin has been used for several years to help prevent ketosis in problem herds. We recommend niacin in close-up dry cow programs at a level of 6-12 grams per day and fresh cow rations at a level of 6 grams per day. In addition to prevention of ketosis, niacin can also improve feed intake and microbial protein production. We have also seen evidence of niacin elevating milk protein synthesis when used in high fat diets during early lactation.

Nutrient Guidelines For Close-up Dry Cows And Fresh Cows

<u>nutrient</u>	<u>close-ups</u>	<u>fresh cows</u>
crude protein	14-15%	19-20%
undegradable protein	35-38%	38-40%
N.E. lactation (Mcal/lb)	.68-.70	.80-.84
calcium	.40-1.80%*	.8-1.0%
phosphorus	.4-.5%	.5-.6%
magnesium	.3-.5%*	.3-.4%
potassium	.8-1.2%	1.0-1.4%
sulfur	.25-.45%	.25-.30%
copper	25ppm	25ppm
zinc	80ppm	80ppm
manganese	60pp	60ppm
iron	100ppm	100ppm
selenium	.3ppm	.3ppm
Vitamin A (IUs/day)	160,000	200,000
Vitamin D(IUs/day)	40,000	50,000
Vitamin E(IUs/day)	1,000	1,000
niacin (g/day)	6-12	6

*: Calcium, magnesium and sulfur must be elevated when feeding anionic salts

The incorporation of rumen bypass protein in close-up dry cow rations is usually necessary to balance protein requirements and to assist in consumption of bypass protein sources after calving. We formulate close-up dry cow rations to contain a minimum of 35% high quality rumen bypass protein, and fresh cow rations to contain a minimum of 38% high quality rumen bypass protein. Since many bypass protein sources are not very palatable, it is even more critical that they are present in the close-up dry cow ration to facilitate maximum consumption in early lactation cows.

Adequate effective fiber (that fiber which stimulates cud chewing) from long-stemmed forage is a must in close-up dry cow rations in attempting to minimize abomasal displacements and maximize appetite after calving. We recommend a minimum level of 8-12 lbs. of long-stemmed forage and a maximum of 20-25 lbs. of silage in close-up rations.

Avoiding abrupt ration changes by feeding similar ingredients as contained in the fresh cow ration is critical in close-up dry cow rations to shorten ruminal adaptation time and to enhance appetite

after calving. A portion of the fresh or high group ration (approximately $\frac{1}{3}$ to $\frac{1}{2}$ of the diet dry matter) without rumen buffer works extremely well.

Heavily fortified (yet balanced) vitamins and mineral levels during the close-up period can certainly minimize transitional stress by alleviating problems such as retained placenta, uterine infection, droopy cow syndrome, etc. Adequate levels of vitamins and trace minerals are also necessary for maintenance of a healthy immune system, normal colostrum quality, and good reproductive efficiency.

Summary

In assessing whether a particular producer is successfully minimizing transitional stress in close-up dry cows a few questions come to mind:

- Do your cows freshen in high gear and eat like there is no tomorrow?
- Does their milk production jump rapidly without significant loss of body condition?
- Do you have a minimum incidence of freshening problems, i.e. displaced abomasum, ketosis, off-feed, retained placenta, milk fever, etc.?

A good transition feeding program can help any producer respond with a confident "yes" to each of these questions.

notes

Facts And Fallacies About The Uterus After Calving

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Unbelievable. That single word best describes the structure and function of what is one of the most complex organs in the body. The uterus is simply unbelievable. It accepts a substance foreign to itself, blocks the normal body defenses designed to destroy foreign “invaders”, and nourishes, protects, and sustains the developing calf while the uterus grows from a diameter of about one inch to 24 inches or more. When the time is right, the uterus accepts a signal from the calf and transforms itself into a delivery system, forcibly expelling the calf, and then begins an amazing process to prepare itself for a repeat of the whole cycle. It’s that recovery process between calving and pregnancy that is so critical to a profitable dairy enterprise, and is so misunderstood.

Following calving the uterus must expel the fetal membranes and fluid that surrounded the calf, reabsorb the small concentrated button-like areas where the calf and mother exchanged nutrients and oxygen, repair the uterine lining, and shrink to a size ready to accept the next embryo. The normal uterus will lose more than 80% of its size at calving within a two to three-week period. The process controlling this recovery is complex, and filled with a variety of control systems sending signals between the uterine glands, the ovaries, several areas in the brain, and the adrenal glands (located by the kidneys).

Other hormones associated with milk letdown have an influence on uterine muscular activity though the hormone oxytocin, which also plays a role in recovery. Plenty can go wrong, but I’m always amazed at how much goes right – frequently in spite of, rather than because, of what we caretakers do.

The rate of involution, a term that encompasses uterine shrinkage, fluid loss and tissue repair, is an indicator of the overall status of the recovery. Anything that slows involution will delay or prevent a successful subsequent pregnancy. Traditionally, we caretakers have concentrated much of our energy on dealing with uterine infections through the use of antibiotics and other treatments as our attempt to “prevent” or “cure” them. The most frequent question most dairy veterinarians are asked is “which

medicine should I use, Doc?” Many of the most popular concoctions have romantic or powerful names, pretty colors, secret ingredients, and a long list of testimonials from your colleagues singing their praises. The frustration associated with trying to get that good cow pregnant drives dairy farmers to attempt anything, even when it makes neither medical nor economic sense.

Almost all cows will become contaminated and develop a uterine infection at the time of calving. The cervix, the valve that seals the uterine interior from the outside environment, opens wide at calving to allow the calf to pass, thereby admitting whatever bugs are in the neighborhood, and the neighborhood has plenty. Multiple bacteria types, including bugs such as the coliforms, Streptococci, Actinomyces pyogenes, Fusobacterium necrophorum, and Bacteroides melaninogenicus, are found in uterine cultures during the post partum period. It is not unusual to find bacteria present in over 90% of uterine samples at 15 days after calving, close to 80% at 30 days, 50% at 45 days, and about 10% at 60 days. You might conclude that with these kinds of infection rates you should treat everything with antibiotics or antiseptics immediately. Don’t.

Why not? Before I explain why I believe across-the-board treatment is not in your cows’ best interest, answer two questions for me:

First, which medication do you want to use? You name it, someone has infused it, and I can find someone who will swear by it. Antibiotics infused into a cows uterus act a lot like antibiotics injected into muscle, but with less predictability. They move into the blood, course through body organs, and find their way into milk. Residues are always a concern, both in meat and milk, following uterine infusion. The only question is when will they be there and whether they will be at a level that can be detected. Systemic treatment, using either IM or IV regimens, also enjoys its advocates, and has similar residue concerns. Other non-antibiotic products, including uterine boluses, antiseptic infusions, and hormone treatments have been promoted and defended, but all of these treatments lack definitive research results

FALLACY:

The uterus is like an old sock, simply receiving and holding the calf until it is ready to be born.

FACT:

The uterus is a dynamic, complex organ with interactions between the walls and deep tissues, the ovaries, the brain, and other organs within the body.

FALLACY:

I can treat the signs of uterine dysfunction, such as abnormal discharge, poor involution, anestrus, etc., effectively and economically.

FACT:

A dysfunctional uterus will never approach the same level of performance as one that is normal, regardless of treatment. There are treatments that can improve fertility, but prevention of the problem is the best method, and prevention of most uterine problems is possible and profitable.

FALLACY:

Treating by uterine boluses, infusions, hormones, or systemic therapy will improve subsequent fertility.

FACT:

No treatment returns an abnormal uterus to the same fertility level as compared to a normal uterus. There are studies which support one treatment over another, and other studies with contradictory results, such that there exists no definitive evidence that one product or procedure is more effective than another. Best management practices prevent rather than treat problems.

FALLACY:

I can treat the signs of the problem, such as retained fetal membranes or a foul smelling discharge and solve the problem.

FACT:

That approach is like taking aspirin to fix a headache that results from wearing a hat that is too small. The hat size needs to be changed, not better aspirin developed.

FALLACY:

Vaginal discharge is a sign of a uterine infection.

FACT:

Lochia is a normal and expected vaginal discharge during the early post partum period. Discharge that is very watery, in large quantities, and foul smelling does represent a problem.

FALLACY:

Red medicine works best.

FACT:

Color is not a factor in determining the effectiveness of a medication, and no medicine returns the abnormal animal to normal performance.

FALLACY:

Local uterine treatment will not result in milk or tissue residues. Non-antibiotics will not result in residues.

FACT:

Any medication you put in the uterus will find its way into the general circulation, and will result in tissue and milk residues.

FALLACY:

Dry cows are the perfect group to get rid of all of the junk feed on the dairy because they don't produce any milk and don't need the good stuff anyway.

FACT:

These are your most important animals on the farm, and they have real need for adequate support in order to be prepared for a successful lactation with normal fertility. Good management from the last third of the previous lactation through the first three weeks of the subsequent lactation will result in excellent milk production and reproductive performance.

FACT:

Metritis, pyometra, and forced culling from poor fertility is in large part preventable. Maternity pen sanitation, good hygiene if obstetrical procedures are needed, careful selection of which cows get treated and the treatment methods, including technique and sanitary practices, and dry cow nutritional balance will result in the post partum period being a pleasure, not a problem.

demonstrating their benefits. In fact, there are research results published to support or detract from almost every product and treatment program ever suggested.

Why can't we develop the data to definitively answer the questions about treatment? One reason is that interpretation of results is difficult. There are three potential outcomes to any treatment; the treatment may help and improvement will follow; it may have no beneficial nor detrimental effect; or the treatment itself can be detrimental. All three can happen with a single treatment in a herd simply by chance, and it requires well designed trials comparing treatments to untreated controls to recognize the real effects of treatment. As you might imagine it is difficult to find cooperators that are willing to leave an adequate number of untreated controls in their herd for a treatment trial.

Another problem is our inability to precisely identify those animals in need of therapeutic assistance from their normal herdmates. The high percentage of positive culture results from uterine samples demonstrates the poor specificity of that test in identifying animals in need. Rectal palpation, vaginal examination, discharge evaluation, fever, appetite and other methods are commonly used to identify and initiate therapy in poorly involuting animals, but they are not perfect. The earlier you examine the animal, the more imprecise the decision to treat or leave alone can be, and you will end up treating many that didn't need it, a disadvantage to your economics and your cow's fertility. You also get fabulous recoveries (because they would have been OK without treatment anyway), and a false evaluation of the therapy.

If I told you that two dairies of the same size had different abortion rates last year, and although Dairy A's rate was 2% higher than Dairy B's, I concluded that Dairy A was in better shape than Dairy B, would you disagree? Would you change your mind if I added that Dairy A had 55% of the herd pregnant, and Dairy B only had 30%? I'm sure you will agree that pregnancy is an essential qualification for risk of abortion. The same problem exists in treatment

trials; if we don't know which really need it, and mix in large numbers of those that do not, we make interpretation of results very difficult. I've always felt that if "recovery rates" for treatment of infections, cystic ovaries, etc., we high, say over 50% at a two week recheck, then I probably treated a bunch of animals that didn't need it.

Second question: how are you going to evaluate the results? Part of the confusion in evaluating various treatments result from our inability to routinely select the correct goal of therapy. What yardstick are we going to use to measure success?

When I was working as a milker we used to call the vet to come clean cows with retained fetal membranes. Our yardstick of success was to eliminate the tail switch from stinking so that whenever she hit us in the face she would not transfer that wonderful odor to our nose area. By this measure manual removal of a retained placenta was a smashing success, and was a common practice, until some smart person looked at its influence on days open and found treated animals were significantly and adversely affected. We were simply using the wrong yardstick to evaluate the therapy.

Need another example? Twenty years ago or so veterinarians were regularly called to bring anestrus cows into heat, and occasionally they used an injection of a hormone available at that time that made them express heat signs. It worked – if a cow acting like she was in heat was your goal. If you really wanted a pregnancy, however, the use of that product was counterproductive.

I recommend against treating every cow. In my experience the routine use of uterine boluses creates problems where none existed, and simple discontinuing that practice directly improves herd fertility. Similarly, routine infusions result in increased day open. In my hands it appears that a single uterine infusion in heifers early in the postpartum period will increase days open by eight without any improvement of conception rates or numbers getting pregnant. There is ample evidence to be concerned that most treatments administered to normal cows will result in increased days open, and that

our ability to identify normal is imprecise. Additionally, there is no clear scientific evidence that any given treatment is beneficial to the majority of animals being treated. Animals that are off feed, feverish, with very thin watery and foul smelling discharge need and will benefit from treatment! There exist other uterine problems that can be treated with improved performance as the outcome. My point is simply that your time is better spent preventing the problems in the first place, with proven effectiveness, rather than spending your time, money, and effort using treatments which do not always result in improvement, and which may be detrimental to the animals subsequent performance.

There has been an explosion in our understanding about how to maintain a healthy uterus under commercial dairy conditions. Prevention management practices allows us to reduce the numbers of animals needing treatments to less than 25% in most commercial herds, and much lower in exceptionally managed herds. Cow fertility is significantly improved in those that never needed treatment versus those that do. No therapy returns a cow to the level of normal performance. Prove this to yourself by comparing days open, services per conception, and culling rates for normal animals that deliver live calves unassisted, do not retain their placenta, receive no treatment, and are pregnant within two services (my definition of normal) against their treated herdmates.

We now know what many have long suspected: a relationship exists between poor fertility and a number of other cow problems. The risk of poor fertility is increased if the animal has any one or combinations of: milk fever, prolonged but unassisted calving, assisted calving, retained fetal membranes, prolapsed uterus, mastitis, ketosis, fat cow syndrome, displaced abomasum, unsanitary calving conditions, or unnecessary post partum treatment. The key management points to prevent these conditions revolve around energy and protein balance; control of rapid weight gain or loss; proper body condition at calving and into the early lactation period; calcium and phosphorus balance; anion/cation balance of the dry cow ration; trace mineral and vit-

In my hands it appears that a single uterine infusion in heifers early in the postpartum period will increase days open by eight without any improvement of conception rates or numbers getting pregnant.

amin balance; calf size (sire selection); sanitation at calving; and post partum treatment methods.

Heifers must be of adequate frame size, and proper body condition, to successfully deliver a calf while supporting their needs for growth and milk production. High rates of anestrus heifers in the first 70 days of lactation, which were at their proper frame and body condition at the time of calving, represent a ration imbalance or unsuccessful competition with older cows at the feed bunk, or both.

The preparation for the following lactation in cows begins in the last third of the previous pregnancy. This is the time to carefully monitor their body condition and adjust their rations to achieve their ideal condition. An extra bonus to good management is that this period also represents the most economical time to put weight on animals that are underconditioned, and to take weight off of those that are overconditioned.

We now know that our old recommendations to have cows at body condition scores of 4+ during the dry period represented the use of the wrong yardstick. It may have helped them from getting too thin during their first 1/3 of the following lactation, but also lowered both their production and fertility. Cows should be dried at body condition scores of 3-3.5, and calved at 3.5 for maximum production and fertility. Rapid changes in weight, in either direction, are likely to result in fat cow syndrome, which can result in delayed involution, increased uterine infection rates, and poorer recovery.

The dry period is a terrible time to get rid of that junk feed you've got laying around. These are your most important cows on the farm, and this is the most important period in the whole lactation. The ration needs to be carefully balanced for energy, fiber, and quality protein to provide the cow with the ability to deliver a healthy calf, recover from pregnancy, and reach her maximum potential pro-

duction. Adequate trace minerals and vitamins are essential. Prevention of heat stress, corral maintenance to promote feed intake, sanitary bedding, adequate water, and all the other well known husbandry requirements that are frequently missing from dry cow pens are money makers if you use the right yardstick as your goal.

notes

The New Ethic For Animals And The Dairy Industry

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There is an unfortunate tendency on the part of those who use animals to dismiss the new social concern with animal treatment as the irrational ravings of tofu-eating, ginseng-guzzling, urban wimps and bunny-hugging extremists. "Animal welfare is what we already do; animal rights if what they want us to do," one animal scientist said, neatly summarizing the situation. However, what is of paramount importance is that "they" are not just a band of radicals; the new ethic for animals has taken root among society in general. As one cowboy in Kingsville, Texas put it to me: "Hell, Doc, if it were just the damn radicals, we could shoot the sons of bitches!"

My first point, then, is to explain the new ethic and its conceptual roots. Although society has paid formal attention to limiting human behavior regarding animals for over 2,000 years, such attention was restricted to the prohibition of overt, intentional, willful, extraordinary, malicious, or unnecessary cruelty; deviant sadism; or outrageous neglect. For example, not providing food or water. This ethic can be found even in the Bible. For example, in the injunction not to yoke the ox and the ass to a plow together, or in the restriction against muzzling the ox when he is being used to mill grain.

This minimalistic, lowest common denominator ethic was formally encapsulated in the anti-cruelty laws during the 19th century. These laws were as much designed to ferret out sadists and psychopaths – who might begin with animals and, if left unchecked, graduate to venting their twisted urges upon human beings – as to protect the animals for themselves.

This view of prohibiting animal cruelty can be found in Catholic theology where, although animals do not in themselves count morally, animal cruelty is forbidden for its potential consequences for people, since people who are cruel to animals will 'graduate' to abusing people. Interestingly enough, contemporary research has buttressed this insight. The traditional humane or animal welfare movement was also caught up in the categories of kindness and cruelty, and for this reason tended (and still tends)

to simplistically categorize anyone causing animal suffering as 'cruel'. Hence, one can still find activists picketing medical research institutions and carrying signs which say "stop the cruelty" — as if researchers are on a par with people like the serial killers, many of whom did indeed torture animals in their youth.

Within the purview of this traditional ethic, any suffering inflicted on animals for "acceptable," "normal" or "necessary" reasons such as economic benefit, food production, pursuit of scientific knowledge, cures for disease, or, as one law puts it, otherwise "ministering to the necessities of man," was morally and legally invisible, shrouded by the all-encompassing cloak of "necessity." By and large, therefore, the "normal" use of animals for human benefit in research, agriculture, hunting, trapping, rodeo and the like was not the concern of social moral thought on animals.

During the past two decades society has begun to move beyond the overly simplistic ethic of cruelty and kindness and to reach for a more adequate set of moral categories for guiding, assessing, and constraining our treatment of other animals. Perhaps the key insight behind this change is the realization that the overwhelming majority of animal suffering at human hands is not the result of cruelty, but rather, these animals suffer because of normal animal use and socially acceptable motives. To prove this, I ask you to perform a thought experiment. Imagine a pie chart representing the total amount of suffering that animals experience at human hands. Then ask yourself, what percentage of that suffering is the result of intentional, sadistic, useless, deliberate infliction of pain or suffering on the animals for no purpose? Interestingly enough, all of my audiences, be they Montana rodeo people or San Francisco activists, say the same thing — well under 1%. Most animal suffering comes from reasonable human motives and goals. Scientists may be motivated by benevolence, high ideals and noble goals, yet far more animal suffering is occasioned by people acting in pursuit of these motives than by the actions of overt sadists. Confinement agriculturalists may be motivated by the quest for efficiency, profit, productivity, low-cost food and other putatively acceptable goals, yet again, their

activities occasion animal suffering in orders of magnitude traditionally unimaginable.

As we mentioned, the old ethic doesn't apply to these normal, non-deviant uses of animals. This is true not only conceptually, but practically. The limitations of the ethic and the laws based in it were dramatically illustrated when the Animal Legal Defense Fund, a group of attorneys whose *raison d'être* is raising the moral status of animals in society by use of the legal system, attempted to extend the scope of the anti-cruelty laws by a test case. As animal advocates, they generate many fascinating lawsuits which test, press, and expose the limits of the legal system's control over the treatment of animals. In 1985, they brought suit against the New York State Department of Environmental Conservation, that branch of New York State government charged with administering the use of public lands. Specifically, they charged the department with violating the anti-cruelty laws by permitting trapping on public lands utilizing the steel-jawed trap. Since there are no laws regulating how often a trapper must check his trap line, an injured animal could be trapped without food, water, medical care or euthanasia for long periods of time which, according to the plaintiffs, constituted unnecessary cruelty. They were thus seeking an end to such trapping.

Given the laws, the judge made a very wise decision. He opined that the steel-jawed trap was in his view an unacceptable device. But given the way the anti-cruelty laws have been written and interpreted, the actions of the agency in question did not constitute cruelty. After all, steel-jawed trapping is widely done as a means to achieving pest control, supplying fur, and providing a recreational pastime. Thus, the activity of trapping is a legitimate one from a legal point of view, and does not fit either the intent, judicial history or statutory language of the anti-cruelty laws. If one wishes to change the status of the steel-jawed trap, the judge asserted, one should therefore go not to the judiciary, but to the legislature. In other words, one must change the laws, i.e. the social ethic.

This case neatly illustrates some important features of what is happening in social thought: First of all, social thought is moving beyond cruelty. Second, society is attempting to create new social rules and laws to protect animals. (The best illustration of this point is the passage in 1985 of two new federal laws to protect laboratory animals after society realized that the research community was not regulating itself.) Third, society is moving beyond concern about traditional cute and cuddly animals to concern about all animals who can suffer.

Why is society suddenly concerned about the 99% of animal suffering that is not the result of deliberate cruelty? One can speculate as to why the demand for such an ethic has emerged only recently.

First, society has just lately focused its concern on disenfranchised human individuals and groups, such as women, Blacks, the handicapped, and the Third World. This same emphasis on moral obligation rather than patronizing benevolence toward the powerless has led to a new look at animal treatment.

Second, the urbanization of society makes the companion animal, not the food animal, the paradigm for animals in the social mind.

Third, graphic media portrayal of animal exploitation fuels social concern. As one reporter said to me, "animals sell papers."

Fourth, increased awareness of the magnitude of animal exploitation made possible by technologies of scale inspires massive unease among citizens, who perhaps see themselves being rendered insignificant in the face of techniques, systems and machines that relentlessly reduce the individual — animal or human — to a replaceable quantity. This sense of impotence in the face of forces one cannot even understand, let alone control, can fuel empathy with the animals.

Fifth, numerous rational voices have been raised to spearhead the articulation of a new ethic for animals. Although concern for animals was traditionally seen (with much justice) as largely a matter of inchoate emotion, such a charge cannot be leveled against the numerous philosophers and other intellectuals of today who eloquently and forcefully nudge the social mind in the direction of increasing moral awareness of our obligations to animals.

Sixth, and most important, the nature of animal use has changed significantly. The major use of animals in society was and is, of course, agricultural. Before the mid-20th century, the essence of agriculture was husbandry. People who used animals put those animals into environments for which they were evolved and adapted and then augmented their natural ability to cope with additional food, shelter, protection from predators, etc. Producers did well if and only if animals did well. This is what Temple Grandin has aptly called "the ancient contract" — or as ranchers say: "we take care of the animals and they take care of us." No producer could, for example, have attempted to raise 10,000 egg laying chickens in one building — he would have had all his animals succumb to disease in weeks.

In contrast, when animal husbandry departments symbolically became animal science departments in the 1940s and 50s, industry replaced husbandry, and the values of efficiency and productivity above all else entered agricultural thinking and practice. Whereas traditional agriculture was about putting square pegs in square holes, round pegs in round holes, and creating as little friction as possible while doing so, 'technological sanders' such as antibiotics and vaccines allowed us to produce animals in environments which didn't suit their natures but were convenient for us. For example, we could now raise 10,000 chickens in one building.

Similarly, the rise of significant amounts of research and toxicity testing on animals in the mid-20th century also differs from the ancient contract — we inflict disease on animals, wound, burn and poison them for our benefit, with no benefit to them.

These, then, are the reasons society seeks a new ethic for animals. What form is this emerging ethic taking? Very simply, it asks that the consensus ethic we all share in society be extended to include animals, as it was extended to include disenfranchised humans. Despite an inherent tendency on our part to magnify and stress differences in the ethical positions among diverse persons in a society, the similarities and agreements in ethical principles, intuitions, practices and theories that obtain in society far outweigh the differences.

This phenomenon is true for many reasons. In our society, most of us are brought up and steeped in the same Judaeo-Christian, individualistic heritage. In addition, we live under the same set of laws, which encode much of that morality in ways that guide and shape our theories and practices. Finally, it is evident that we could not live and function together if we did not implicitly share a very significant set of moral guidelines. This point is typically unnoticed precisely because it is always there and it works. What is noted and remembered are the situations in which the point does not work and about which we are greatly divided — issues like capital punishment or abortion. If you X-ray very different looking people, what you see is very similar; if you X-ray a Hassidic rabbi and a Wyoming rancher morally, the same thing occurs.

What aspect of our social ethic is being extended to animals? In our democratic society, the consensus social ethic effects a balance between individuality and sociality, or more specifically, between individual rights and social utility. Although most social decisions and policies are made according to that which produces the greatest benefit for the greatest number, this is constrained by respect for the individual. Our ethic builds fences around the individual to protect the sanctity of his human nature, or telos, from being submerged by the general or majority welfare. Thus, we cannot silence an unpopular speaker, or torture a terrorist to find out where he has planted a bomb, or beat a thief into revealing where he had hidden his ill-gotten gains. These protective fences around the individuals are rights; they guard fundamental aspects of the individual even from the general good. Specifically, these rights protect what is plausibly thought to be essential to being a human — believing what you wish, speaking as you wish, holding on to your property and privacy, not wanting to be tortured, and the like. These rights are fueled by the full force of law.

One major step toward extending the ethic to animals, not difficult for the average person to take, is the realization that there exists no good reason for withholding the ethic from our treatment of animals. In other words, there is no morally relevant differ-

ence between humans and animals that can rationally justify not assessing the treatment of animals by the machinery of our consensus ethic for humans. Not only are there no morally relevant differences, there are significant morally relevant similarities. Most important, most people believe that animals are conscious beings; that what we do to them matters to them; and that they are capable of a wide range of morally relevant experiences — pain, fear, happiness, boredom, joy, sorrow and grief. In short, they experience the full range of feelings that figure so prominently in our moral concern for humans.

Not only does ordinary common sense accept as axiomatic the existence of consciousness in animals, it also takes for granted that animals have natures (telos) — “fish gotta swim, birds gotta fly,” as the song goes. Again, it is not difficult to get ordinary people to admit that the central interests of animals’ natures should be protected from intrusion; even if we use animals, animals should live lives that fit their natures. It is not an accident that a major confinement chicken producer like Frank Perdue did not, in his advertising, show the public how he really raises chickens. Rather, he ran ads showing open barnyard conditions which affirmed that he raised ‘happy’ chickens. Ordinary people — even those who are not animal advocates — are appalled by veal calves in confinement, wild animals in tiny cages, or primates in austere and deprived environments. Polls indicate that 80% of the general public believe animals have rights. Well over 90% of the 7,000-10,000 ranchers I have addressed also believe this. Indeed, the president of the Colorado Cattlemen’s Association remarked some years ago at a closed seminar for agriculture leaders that, “If I had to raise animals the way these veal people do, I would get the hell out of the business.”

In summary, society has gone beyond the anti-cruelty ethic and has expressed concern that animals used by humans not suffer at our hands, and

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indeed, that they live happy lives. The rights of animals, as determined by their natures, must constrain and check animal use. Convenience, utility, efficiency, productivity and expense are not sufficient grounds for overriding animals’ rights. This idea is tentatively encoded in some legislation, and it is affecting animal husbandry without being legislated; the extensive efforts over the past decade to

create zoos that respect animal natures give testimony to the spread of the new ethic. Furthermore, it appears that society is actually willing to give up certain animal uses and conveniences for the sake of the animals. The abandonment of the Canadian seal hunt, the massive social rejection of furs, and the rejection of cosmetic testing on animals by many companies, all without legislation, attest to the growing hold of the new ethic.

Considering what we have discussed, it is patent that the dairy industry should undertake a proactive, critical self-examination before society as a whole is galvanized by some sensational event or expose to legislate in an ill-informed way. The Minneapolis-South St. Paul stockyard situation could well have had that effect.

You must become proactive in the face of the emerging ethic, not reactive and defensive. You must try to separate the legitimate from illegitimate criticisms directed at your activities, and correct the real deficiencies in an anticipatory way. It is far cheaper and easier to deal with things yourself than to have changes legislated by well-meaning but ignorant people who don’t know hay from straw or foals from ponies. If legislation is necessary to correct abuse, it is far better that it come from you than that it be forced upon you. Legislation coming out of a crescendo of public pressure is invariably flawed.

If society can generate sufficient concern to pass legislation that mandates the control of pain of rats and mice — the overwhelming majority of animal used in research — imagine what a groundswell of concern

could be evoked about dairy cows, the animal which has been called "mother of the human race."

Let us examine the status and problems of the dairy industry proper in the face of this new ethic, leaving aside the veal production issue for another discussion.

There is, historically, probably no area of traditional, extensive, pre-industrial agriculture where the contractual, "we take care of the animals, the animals take care of us" ethic was more fully realized than in dairy farming. What made dairy an especially good example of the contract between animal and man was the early realization that gentle, compassionate treatment of cattle leads to significantly better milk yield. Science has recently confirmed what common sense knew for sure — that the variable that correlates most highly with milk production is the personality of the herdsman, and that women generally make the best stockmen.

Thus, while few people considered range beef cattle to be, as it were, members of the family, such was not the case with dairy cows. A colleague of mine who grew up on an extensive dairy farm recalls that there was no bigger honor in his family than to be named after one of the favored cows. Students still tell me of their father's crying after the death of a favorite cow. Since dairy cattle were raised for their products, not their meat, the element of killing was not central to such farming, and animals often lived for a long time, even beyond what could be justified by productivity alone.

This view of dairying entered popular culture and, in my view, still makes the general public favorably disposed towards milk production. The image of Bossy happily chewing her cud is a cliché, often depicted in cartoons, and the Carnation Company has indelibly stamped an entire generation or two with the pastoral picture of "contented cows." Few members of the general public would agree with the activist statement I heard at an animal welfare conference — "I can think of nothing more disgusting than drinking the milk of another species." Thus, the dairy industry would be wise to confirm this perception of concern, not erode it.

Yet there exist both genuine welfare issues and issues growing out of uneducated public perception

which could harm the enviable position of dairy in the public mind. In either case, however, these problems must be laid to rest. As the animal industry often remarks, in animal welfare perception is reality. Unfortunately, as Albright has forcefully pointed out, "very little organized U.S. research on dairy animal welfare is under way. A library CRIS-USDA computer search from 1978-1986 with such key words as dairy, cattle, cow, calves, calf, veal, welfare, humane, or well-being revealed four projects active and pertinent to this discussion."

1. LARGE DAIRIES

One of the most dramatic changes in dairies, directly relevant to public perception of the industry, is the rise of large intensive dairy operations, with up to 3,000 cattle maintained in relatively small acreages. The small dairy farmer, with names for his cows, is a vanishing breed, as land costs, labor costs, and capital investment costs increase. The public tends, with some justification, to equate large operations with lack of concern and attention to individual animals. On the other hand, proponents of large, well-capitalized, intensive operations argue that their operations, possessed of adequate money, and unlike small operations, not running on a shoestring, are thus able to afford sufficient labor to look after the cows, and actually provide for more inspection of animals, since mechanization and automation have removed much of the 'scut' work. Arave and Albright have argued that this is true for mastitis control. Supporting this view is the fact that, unlike sows, cows are relatively expensive and highly productive (the modern cow can produce 10 to 36,000 lbs. of milk per year), and thus careful attention to the animal also benefits the producer.

Albright has argued that mechanization is no substitute for stockmanship, a point echoed by others. Research into this question would be highly desirable. If it is true that large operations increase individual attention to animals, such research could blunt negative public perceptions of large operations. If it is false, it would probably lead to revisions in industry practice and to better management. Such research might compare small and large dairies in

terms of a variety of parameters related to welfare. My key point is that the public must be convinced that, regardless of size of operation, concern for individual animals is still operative.

One area which feeds the idea of callousness at large dairies, according to Temple Grandin, is the treatment of surplus calves. She informs me that such calves often receive no colostrum and are shipped as young as one day old, before they can even ambulate properly.

Behavioral Knowledge

One of the most needed research areas in dairy cattle is fundamental, basic research into the normal behavior patterns of modern dairy cattle under the open conditions for which they were historically selected, something like what was achieved at Edinburgh by Stolba for domestic swine. This will help in judging the extent to which modern systems meet the animals' natures. Unfortunately, there is no wild population of *Bos taurus* analogous to the population of European wild swine which Stolba used as a basis for ethological comparisons. The closest analogue may be beef cattle maintained under range conditions, or dairy cattle still kept under traditional conditions.

At any rate, methodology must be devised, and research conducted, which will provide researchers with a baseline 'ethogram' of natural behavior for dairy cattle, which can then be used as a rational basis for assessing current systems. Such basic research would be invaluable for welfare concerns. In addition, as Temple Grandin and others have shown, knowledge of fundamental behavior is useful for handling and management.

As we have said earlier, behavior seems to be emerging as a focal point for welfare deliberations. At the same time, cattle show fewer stereotypies than other animals, but do show some. It has been suggested that cud-chewing provides a built-in form of self-stimulation which allows the animal to cope with austere environments, even as gum-chewing has carried generations of students through boring lectures. Given our earlier explanation of the new social ethic, such basic knowledge of cows' behavioral needs and natures is vital.

2. CALF WELFARE

Some of the major potential hotspots for the dairy industry come from the treatment of calves. Most female calves are used as replacements for dairy cows. Various practices associated with raising such calves have been criticized on welfare grounds. One such issue is the very early separation of calf from mother. Public perception suggests that such a separation is stressful to both animals, since cattle under extensive conditions can suckle for some seven months.

According to Albright, such separation is necessary in order to expedite human-cow interaction — cattle reared by dams or by nurse cows with no human involvement "are more difficult to calm down, have greater flight distances,... circle continuously in the holding pen, and are difficult to train to the milking routine." In other words, the early stress of separation may increase the animals' welfare later when it becomes a dairy cow, since humans have become surrogate mothers to the calves, as Albright puts it. On the other hand, the average person sees 'removing a baby from its mother' as paradigmatically abusive, even cruel.

It is obvious that the practice of separating calves at an early age from mothers should be further researched, with regard to stress on both cow and calf, and ways of mitigating that stress should be examined. Given that virtually all dairy farmers effect such separation, the issue is of considerable significance.

A related question concerns the optimal time for removing calf from cow. This is currently disputed, most notably with regard to the provision of colostrum. Some dairy farmers leave the calf with the mother for up to three days to allow the calf to suckle, to permit a mother-offspring relationship to form, and to render the cow's milk free of colostrum and thus able to be sold. In contrast, others separate the calf immediately and deliver the colostrum through a nipple-pail or bottle. Although it may seem more welfare-friendly to allow the cow and calf the longer period to bond, one can argue that separation of the calf after three days, rather than at birth, causes greater trauma. According to Albright:

"When the calf is left with the cow three days or more, it is more difficult to separate the pair. Excessive bawling, fussing, and breaking down fences occur when maternal urges are then denied, and the cow will fret excessively when separated from the calf, resulting in decreased milk production."

Again, this points towards the need for further research in minimizing the stress of separation. It is also clear that close attention to separation of calf from dam by the public could generate generate very bad publicity for the industry, given the sanctity of the mother-offspring relationship for common sense. Research into raising calves on nurse cows, as is sometimes done in the beef industry, should perhaps be undertaken. Dairy bulls raised on nurse cows grow up less dangerous because still fearful of humans.

Another welfare issue concerns the housing of calves. In the U.S., it is most common to raise calves for about three months in individual pens or hutches to which the calf may be tethered. Although such hutches are an improvement over crates, as animals in fenced-in hutches can move freely, they are still offensive to many people who dislike the restricted space and isolation from other animals. Despite the fact that probably the major purpose of individual housing is disease prevention and ease of observing individuals, many dairymen will allow calves to interact with calves in adjacent pens or hutches. Roy has argued that calves are happier when they can see one another, and most dairymen with whom I have discussed this issue tend to agree. Outside hutches reduce calf mortality over inside ones.

Supporters of individual housing argue that dairy calves do better and develop normally if they are kept individually until weaning, especially in outdoor pens. They cite higher survival rates, reduced disease and reduced tendency for persistent intersucking among calves raised this way. Albright has argued that the vice of intersucking which is prevalent in Europe is a function of early group housing.

A different view is expressed by Kilgour and Dalton, who favorably cite work by Sambras to justify the importance of keeping calves in groups to ensure

appropriate resting behavior, social and activity behavior:

"The calf's surroundings should provide plenty of stimuli to allow exploration and play."

Similarly, Fraser asserts that:

"Individually reared calves cannot interact much with one another and long periods of social isolation lead to failure to develop normal social behavior."

Strangely enough, some research has shown that calves individually raised in isolation, though indeed subject to a chronic stressor, nevertheless produce more milk as adults. This is open to many interpretations, ranging from the simple notion that this is a clear case where individual productivity is not a mark of welfare, to the complex notion suggested by Albright that:

"Isolation stress has an organizational effect on the ontogeny of the hypothalamo-hypophysial-adrenal system of neonatal calves. The resultant stronger response to adult stressors could increase milk production."

In general, given the diversity of opinion cited above, as well as the strong tendency of the non-agricultural public to react negatively to isolation of calves, research and public education should continue in this area. Ideally, such research could generate group systems which do everything that isolation does, but allows the calves to enjoy social interaction. According to Fraser:

"With further refinement of management procedures, [straw-based] systems are likely to [become]... the normal method of calf housing."

3. HOUSING SYSTEMS

The dairy industry in the U.S. employs a wide variety of housing systems for dairy cattle, ranging from highly extensive, very traditional pasture systems, to stanchion or tie-stall housing, to freestall housing. There are positive and negative features relevant to welfare associated with all systems, but some seem to be more problematic than others.

The system of greatest concern is probably tie-stalls, where the animals are tied in one place for

long periods of time. Tie-stalls are used almost exclusively in the Midwest and Northeast. Although the apparent historical motivation for tie-stalls has been concern for the well-being of the cattle as well as reduction of labor, with tie-stalls allowing for ease of observation and inspection of the cows, the fact that the animals are unable to move and unable to engage in normal

behavior, notably grooming, makes tie-stalls a very plausible and inevitable target for social concern. Whereas a range cow will walk over 6,000 meters a day, a cow in a tie-stall is clearly prevented from such exercise. In addition, the cow's social nature is frustrated by such housing systems. Getting up and lying down can also be a problem in poorly designed stalls. Many tie-stall operators will let the cows out onto pasture or dry lots for one to five hours a day when weather permits, but will keep them inside during bad weather.

Many dairy cattle, especially in the West, are kept in drylot conditions, in outdoor dirt pens in groups. The cow's social nature is expressed, and she can exercise. The problems with dry lots are similar to problems of feedlots: lack of shade, lack of shelter from wind and snow, poor drainage, and general lack of protection from climatic extremes. Some farmers do provide shade and cooling by use of sprinklers. In general, cattle withstand cold stress better than heat stress.

Freestalls have gained in popularity since their invention in 1960. In such systems, cows can be in their own bedded stalls and move freely into concrete or earth yards where they receive food and water. Poor flooring in these systems can lead to foot and leg problems. Given a choice, dairy cows prefer other flooring over concrete. Research is needed into flooring which reduces slippage and injury, and into more effective sanitizing systems for waste removal. Poor hygiene in stalls can also cause masti-

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tis. Again, research is needed to improve the systems.

One problem with all of the systems described above is they fail to allow for grazing on pasture, an activity for which cattle have evolved and which, if permitted, they will spend 8-10 hours a day doing! (Indeed, one can argue that the domestication of cattle resulted precisely from their ability to convert forage to food consumable

by humans.) Recent Swedish legislation aimed at respecting the rights of animals following from their biological natures stressed the need for cattle to graze, and indeed granted cattle the right to graze, in perpetuity. It is likely that public opinion in the U.S. similarly favors the grazing of cattle. Few pastoral images are as powerful and pervasive as that of cows on pasture.

In any case, systems of housing which respect the animals' natures should be sought. I do not think that the new ethic will accept total confinement of cattle.

4. OTHER WELFARE PROBLEMS

Castration, Dehorning and Branding – As in beef cattle, dehorning is a problem, as is castration without anesthesia of bull calves. Most operators do not brand dairy cattle.

Tail-Docking – Over the last few years, docking of tails in dairy cows has gained in popularity in the U.S. and Canada. It is alleged that tail-docking reduces mastitis and somatic cell counts. This is often accomplished by elastrators. Allegedly, the procedure is painless and keeps the cow from flinging manure. Conversations with dairy specialists, dairy veterinarians, and a lactation physiologist have convinced me that there is absolutely no scientific basis for claims about the benefits of tail-docking. Problems with mastitis are largely a function of hygiene, arising when animals are regularly down in unclean stalls. Removing the tail is another example of attempting to deal with what is a problem of human

management by mutilating the animal — e.g. ‘devo-cialization’ of dogs, declawing of cats, and docking tails in piglets. In this situation, however, unlike the others, the procedure will not even deal with the problem. Indeed, removing the tail will cause additional suffering to the cow, since it can no longer deal with flies!

Not only is docking the tail in fact not curative, it can exacerbate the problem. The use of elastrators, contrary to the belief of some farmers, is quite painful. Use of the elastrator can also cause infection, death and decreased milk production. In purely prudential risk-benefit terms, then, it is irrational to choose to dock the tails, and since there is no potential benefit from the procedure, the farmer is not rationally warranted in taking any risk whatsoever. The same point, of course, holds regarding surgical docking of the tail.

Indeed, there is reason to believe that docking the tail is likely to increase the very problem that the farmer is trying to eliminate, namely high somatic cell counts. Kilgour and others have reported that stress elevates SCCs in dairy cattle, and the use of the elastrator and the subsequent pain and distress that it causes the animal would certainly represent a stressor, as would any resultant infection. Furthermore, since stress results in immunosuppression, an animal experiencing the docking procedure would surely be more prone than ever to mastitis, since its immune system is being compromised.

It appears to me that the non-invasive alternative of clipping the tail switch should work as well as docking if there is anything to the theory implicating tails in mastitis. The issue should be definitely dealt with as a welfare concern.

Mastitis and Lameness – According to Fraser and Broom, lameness and mastitis are the two major welfare problems in dairy cattle, and that there is a positive correlation between the incidence of both diseases. Lameness has in turn been tied to high protein and high concentrate diets. Lameness can be reduced by hoof trimming and foot baths, and by attention to flooring, but much remains to be discovered about the conditions which lead to indi-

viduals being likely to become lame. A good deal of lameness is a result of laminitis. Thus, we have a major tissue of researchable issues here, preferably undertaken in tandem with research into improving stall housing and controlling mastitis. Many of these problems can currently be handled with good husbandry and labor which is ‘cow smart’. The challenge, as in all of modern agriculture, is to make the systems ‘idiot-proof’ in the context of larger and larger operations. Research into better flooring, waste disposal, sanitation, and diet would help create systems which are welfare-friendly, even when stockmanship is not perfect.

Downer Animals – The dairy industry is probably the major source of downer animals, and has tended to block legislation against this horrendous practice. While increasing numbers of dairymen are beginning to realize that nothing is more erosive to the contented cow image of the dairy industry than transporting and then dragging a downer cow with a tractor or loader to the kill floor, other elements of the industry have turned a blind eye to the problem. Most dairy downers are probably a result of calcium-phosphorus imbalance leading to milk-fever (hypocalcemia).

Animals that are down should be killed on the farm and not transported. As one rancher put it, “we should eat our mistakes.” The industry should proactively develop or support legislation outlawing it. Both state and federal initiatives are pending regarding downer animals. Not acting decisively on the downer issue is probably the greatest current threat to the dairy industry in terms of public perception, and is also the most morally reprehensible practice.

Future Technology – Future technology is moving quickly into the dairy industry. All technological innovation can have major implications for the well-being of the cows. Consequently, all new innovation must be researched in terms of welfare implications at the same time they are being researched for productivity and efficiency.

The rise of automated computerized milking should be carefully monitored. It has been argued that “this could allow the elimination of the milking parlor, because cows could at their leisure enter

stalls to be milked automatically. More frequent milking would increase production and place less stress on the udder. An important benefit would be to allow the stockman to spend more time observing and tending his animals and less time on routine laborious work." On the other hand, such an innovation could go wrong in many ways, lead to less attention to the animals, and further erode the bond between humans and farm animals.

Genetic engineering can also cause problems. Recent unpublished work on double-muscling led to unexplained weakness and paralysis in calves. Other animals (pigs and chickens) engineered for increased size have shown a variety of problems, notably foot and leg problems, since foot and leg strength did not increase in proportion to the additional size. Cloned calves have been extremely large at birth, leading to birthing difficulties, and have shown other problems, including alleged 'stupidity'. In all genetic engineering programs, the resultant animals should be no worse off than their parent stock, and should be carefully monitored. Productivity should not be pushed at the expense of welfare.

The use of BST and other similar growth hormone innovations developed through biotechnology should also be monitored for effect on cattle well-being. It has been argued that the use of BST will amplify a problem already prevalent in the dairy industry as a result of artificial insemination. In evaluating A.I. Sires, a major criterion employed is the first lactation production of the bull's daughters. Unfortunately, a bull may be bred to thousands of cows before an evaluation can be made of the longevity of his daughters. The result is strong selection pressure for high first lactation production and weak selection pressure for longevity, a major factor in

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efficient production. We are thus selecting for a 100-meter dash cow, forgetting that the most profitable cow is the marathon cow. Thus, many cows are culled before they reach their (theoretically highest) fifth lactation, during the third lactation. BST could augment this problem. Canadian research showed that "BST treatment was associated with an increased culling rate presumably as a result of increased

stress associated with higher milk production." The study showed that while BST increased milk production by 14.4%, it increased culling rate by 45%

According to this argument, this dramatic rise in the culling rate as a result of the injection of BST is further confirmation that we have, through natural selection, bred cows to produce a level of BST which jeopardizes their chances of surviving until their most productive years. Injecting additional BST makes matters worse. The use of BST definitely increases the incidence of mastitis in dairy cattle perhaps because the animals are giving more milk and the lactation ducts are more patent and thus more susceptible to bacterial invasion. Social acceptance of BST has of course been highly equivocal. Widespread public knowledge of the deleterious consequences of its use to the animals could seriously harm the industry's stature.

Conclusion

The dairy industry, by and large, has not been the target of negative publicity, except as the source of downer cattle, as we discussed earlier. The problems we have discussed should be aggressively dealt with in order to preserve the industry's enviable position in the public mind and, more importantly, to preserve the fundamental decency hitherto built into our ancient contract with these animals.

notes

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