# DAIRY DAY 1997

Report of Progress 792

K-STATE Kansas State University AGRICULTURAL EXPERIMENT STATION COOPERATIVE EXTENSION SERVICE

# *The 1997 Annual*

# *KSU DAIRY DAY*

Friday, October 24, 1997, Pottorf Hall — CICO Park
(Riley County Fairgrounds), Manhattan

| | |
|---|---|
| 8:00 A.M. | **Registration - Visit Exhibits**<br>John Shirley, KSU, Program Chairman |
| 9:50 | **Welcome** - Jack Riley, Head, Animal Sciences and Industry, KSU |
| l0:00 | **Reproduction Management** -<br>J.S. (Jeff) Stevenson, KSU |
| 10:15 | **Managing the Nutrition Program for Cow Comfort** -<br>J.R. (Dick) Dunham, KSU |
| 10:30 | **Cooling Cows in the Summer** -<br>J.F. (John) Smith, KSU |
| 10:45 | **Flushing Manure Systems for Dairy Facilities** -<br>Joe Harner, KSU |
| 11:00 | Key Note Speaker - **Dr. Gordon Jones, Oconto Falls, WI**<br>**Cow Comfort in Freestalls** |
| 11:50 | LUNCH (Courtesy of Monsanto) (Ticket at Registration) |
| | ***** Visit Exhibits ***** |
| 1:05 P.M. | **Quality Milk Awards** - J.R. (Dick) Dunham, KSU |
| 1:20 | **Cow Comfort in Freestalls** (continued) |
| 2:10 | **Questions — Dr. Gordon Jones, Oconto Falls, WI** |
| 2:30 | **Adjourn - Visit Exhibits** |
| 3:00 | **Self-Guided Tour - Dairy Teaching Research Center (DTRC)** |

***"A special "THANKS" to the Exhibitors who support KSU Dairy Day"***

# FOREWORD

Members of the Dairy Commodity Group of the Department of Animal Sciences and Industry are pleased to present this Report of Progress, 1997. Dairying continues to be a viable business and contributes significantly to the total agricultural economy of Kansas. Wide variation exists in the productivity per cow, as indicated by the production testing program (Heart of America Dairy Herd Improvement Association [DHIA]). The Heart of America DHIA began business on January 1, 1995, by combining three labs into one. It is now testing about 113,000 cows per month from Kansas, Nebraska, Oklahoma, Arkansas, North Dakota, and South Dakota. A comparison of Kansas DHIA cows with all those in the Heart of America DHIA program is illustrated below.

**Table I**

**Comparison of Heart of America Cows with Kansas Cows**

| Item | HOA | KS |
|---|---|---|
| No. of herds | 1,145 | 398 |
| No. of cows | 104,195 | 37,157 |
| Milk, lb | 17,957 | 18,757 |
| Fat, lb | 652 | 683 |
| Protein, lb | 584 | 601 |
| IOFC, $ | 1,107 | 1,425 |

Most of this success occurs because of better management of what is measured in monthly DHI records. In addition, use of superior, proven sires in artificial insemination (AI) programs shows average predicted transmitting ability (PTA) for milk of all Holstein AI bulls in service (January, 1997) to be +1,351 lb compared to non-AI bulls whose average PTA was +357 lb of milk. More emphasis should be placed on furthering the DHIA program and encouraging use of its records in making management decisions.

Based on comparisons (next column) from 1995 to 1996 using the Dairy Herd Analyzer, better nutrition reduced loss in income over feed cost by $14 per cow, improved genetics reduced the loss by $2 per cow, but milk quality had no effect. Reproductive performance increased the loss by $3 per cow in the face of a hot 1995 summer. In summary, a net reduction in losses of $4 per cow was achieved from 1995 to 1996.

We are proud of our new 72-cow tie stall barn that was constructed in 1991 through the generous support of Pharmacia & Upjohn, Clay Equipment Company, and Monsanto Company and under the direction of Dr. John Shirley. This new facility gives us the ability to expand our research efforts in various studies involving nutrition and feeding, reproduction, and herd management. The excellent functioning of the DTRC is due to the special dedication of our staff. Appreciation is expressed to Richard K. Scoby (Manager, DTRC); Donald L. Thiemann (Asst. Manager, DTRC); Michael V. Scheffel (Research Assistant); Daniel J. Umsheid; Charlotte Boger; Becky K. Pushee; Lesa Reves; Tamara K. Redding; Kerrie Powell; Gregory Brown; and William P. Jackson. Special thanks are given to Neil Wallace, Natalie W. Brockish, Betty Hensley, Cheryl K. Armendariz, and a host of graduate and undergraduate students for their technical assistance in our laboratories and at the DTRC.

**Table II**

**Comparison of 1995 to 1996 with the Dairy Herd Analyzer**

| Losses | 1995 | 1996 | ± from 1995 |
|---|---|---|---|
| Nutrition, $ | 316 | 302 | –14 |
| Genetics, $ | 28 | 26 | –2 |
| Milk quality, $ | 183 | 183 | +0 |
| Reproduction, $ | 152 | 155 | +3 |
| **Net change, $** | | | –4 |

Each dollar spent for research yields a 30 to 50% return in practical application. Research is not only tedious and painstakingly slow but expensive. Those interested in supporting dairy research are encouraged to consider participation in the Livestock and Meat Industry Council (LMIC), a philanthropic organization dedicated to furthering academic and research pursuits by the Department (more details about the LMIC are found at the end of this publication).

J. S. Stevenson, Editor
1997 Dairy Day Report of Progress

## CONTENTS

# FREESTALL DESIGN AND MANAGEMENT FOR COW COMFORT

*J. F. Smith, G. A. Jones [1], and J. Harner [2]*

## Summary

The design and management of freestall facilities are critical in maintaining cow comfort and high milk production. Dairy producers should be conscious of the factors affecting cow comfort in freestall facilities. These factors include: ventilation, water availability, feed availability, stall design, and stall bedding. Dairy producers should strive to have lactating cows standing to be milked; standing to eat; or lying down, chewing her cud, and producing milk. Managers who take this approach will improve both cow comfort and milk production.

(Key Words: Freestall, Management, Cow Comfort.)

## Selecting Freestall Housing

Selecting the type of freestall housing is an important decision that should be made with the lactating cow in mind. The climate in Kansas allows several options when selecting freestall housing for lactating dairy cows. Some of the options include 2-row, 3-row, 4-row, or 6-row freestall barns. The advantage of 2-row or 4-row freestall barns is access to feed and water. The advantage of 6-row barns is cost; however, producers should be concerned about the level of heat stress and the limited feeding area. Producers building 6-row barns should seriously consider mechanical ventilation. It is essential that freestall barns are constructed properly and stall dimensions are correct. Figure 1 shows the recommended dimensions for constructing freestalls.

Freestalls need to be inviting for the cow to choose to lie in them. Freestalls that are not comfortable for cows usually fail in one of four following areas: 1) lunge space, 2) neck rail positioning, 3) bedding or cushioning, or 4) air or vision.

## Lunge Space

The first reason a freestall may fail is lack of lunge space. A cow needs forward or side lunge space to maneuver in and out of the stall easily. There should be no obstructions in front of the stall above the brisket board if cows are expected to lunge forward. If stall length is limiting, consider wide dividing loops that allow cows to lunge to the side. The length of freestalls varies with their orientation. Single rows of stalls located against a wall need to be a minimum of 8 ft in length. This will allow the cow to lunge forward. When a double row of stalls (head to head) is used, the minimum stall length should be 7.5 ft, provided there is no obstructions that will prevent the cows from lunging forward. Recommended stall width ranges from 45 to 48 inches. Producers in warmer climates should use a 48-inch-wide stall to increase the spacing between cows.

## Neck Rail Positioning

The neck rail must not interfere with the cow entering the stall. That is, it should be far enough back (66 inches) and high enough (44 inches) that the cow can enter the freestall completely with all four feet. Then she can kneel forward and lie down. If the neck rail is too far back, the cow cannot bring her back feet into the stall, and she must lie half in and half out of the freestall. If the neck rail is too low, she also hits her neck on the rail as she

[1]Falls Animal Health, Inc., Oconto Falls, WI.

[2]Department of Biological and Agricultural Engineering.

tries to rise. Producers using mattresses often increase the neck rail height to 46 inches.

### Bedding or Cushioning

Bedding or cushioning is also very important to encourage freestall use. Hard stalls provide very little incentive to choose them over the alleys. The bedding can be anything that provides 4 inches of cushion, absorbs moisture, prevents friction, and does not promote the growth of bacteria. Common beddings include sand, mattresses, composted manure, and wood shavings or sawdust.

When sand is used, with a 4 in minimum, it can be both a base and bedding. Sand provides great cow comfort, drains well, and helps keep cows very clean. Sand will not support bacterial growth. In addition, when a cow steps out of the stall and kicks sand onto the alleys, it improves cow footing. Sand is the "gold standard" for cow comfort; however, a quality sand free of small rocks or pebbles must be used. The major problem is sand in the manure systems. As much as 35 to 50 lb per cow per day will be added to the manure. The only sound advice for sand-laden manure is to plan on sand settling and then removing it from the manure system.

Mattresses can provide a satisfactory base and adequate cushioning. A mattress can be filled with a variety of materials: sawdust, shavings, straw, hay, or ground rubber. The mattress, when properly filled, only provides cushioning. Producers still need to add adequate amounts of dry bedding on top of the mattress to help keep the surface dry and to reduce friction on the hocks. Mattresses are easily the second best things that can be used for a freestall surface, and they may be the best choice for a manure system that cannot handle sand.

Many producers have successfully used composted manure from a solid separator as freestall bedding. If this option is chosen, good facilities and equipment are required to handle and compost the manure for high quality bedding.

Selecting a proper bedding type is important; however, the success of using the bedding will be determined by the producer's ability to keep stalls full of bedding and properly groomed. This will entice cows to use the stalls on a regular basis.

### Air or Vision

Properly ventilating freestall areas is extremely important in maintaining cow comfort. Remember that cows under heat stress dissipate heat through their respiratory tract. We can help the cow with this process by providing ventilation in the stalls. Field observations also indicate that cows prefer stalls and barns that are open and allow them to observe what is happening around them. Avoid structures that hamper air movement or hamper visibility.

### Ventilating Freestall Barns

Freestall housing should be constructed to provide good natural ventilation. Sidewalls should be 12 ft high for monoslope roofs or 14 ft high for Gable roofs to increase the volume of air in the housing area. Ideally the sidewalls should be 75 to 100% open. Fresh air should be introduced at the cow's level. Curtains on the sides of freestall barns allow greater flexibility in controlling the environment around the cow. Because warm air rises, steeper sloped roofs provide upward flow of warm air. Roof slopes for freestall housing should range from 4/12 to 6/12. Roofs with slopes less than 4/12 may have condensation and higher internal temperatures in the summer. Providing openings in addition to alley doors on the end walls will improve summer ventilation. Gable buildings should have a continuous ridge opening to allow warm air to escape. The ridge opening should be 2 inches for each 10 ft of building width. Naturally ventilated buildings should have a minimum of 1.5 to 2× building width between structures.

In the midwest, freestall barns are typically oriented east to west to take advantage of sun angles and provide afternoon shade. Producers who orient barns north to south will have to construct an overhang on the west side adequate to shade stalls in summer afternoons.

Freestall barns should be located as close to the milking center as possible without restricting ventilation. The goal is to reduce the distance cows have to walk to and from the milking parlor. Field observations indicate that distance from the gate of the housing area to the gate of the holding pen should be a maximum of 1200 ft for 2× milking, 900 ft for 3× milking, and 700 ft for 4× milking.

## Reducing Heat Stress

In addition to a cooling system in holding pens, cooling can be provided to freestalls by adding fans and a sprinkler system. Care must be taken to prevent the bedding in the stalls from becoming wet. Typically, a sprinkler system could be located over the lockups, and fans could be used over the freestalls, lockups, or both. The sprinkler system can be put on a timer to reduce water usage. Producers can use either 180° (half-circle) or 360° (full-circle) nozzles. The 180° nozzles work well next to feed lines or bunks to prevent feed from becoming wet. Nozzles that emit from 7 to 30 gal/hr generally are used to conserve water. Producers need to experiment with nozzle type, nozzle size, nozzle spacing, and operating water pressure to determine which nozzles work best in their dairies. Sprinklers need to be operated intermittently using automatic timers to regulate cycle length. Frequently, sprinklers are on for 2 to 3 min per 15 min. The cycle can be adjusted depending on the level of heat stress. Freestalls oriented north to south need sun screen material along the west side to reduce heat load in the building. Orienting freestall housing east to west generally is recommended in the midwest.

## Insulating Freestall Barn Roofs

Insulating the underside of the roof probably began because of poorly ventilated barns that failed to remain warm in the winter. When you try to keep barns warmer than 5° to 10° above the outside temperatures, condensation occurs with dripping. Rather than providing more ventilation and lowering the temperature inside the barn, farmers put insulation under the roof. Insulation may stop the condensation, but it ignores the real problem of poor ventilation. Insulation is sometimes added under the pretense that it will provide cooler summer temperatures. This ignores the fact that insulation, in summer or winter, will retain the heat produced by the cow herself. The answer to condensation and moisture is not insulation, but more ventilation. When a building starts dripping, it is time to open it up more. Today's new naturally ventilated freestall barns should be simply a sunshade in the summer and a wind break in the winter. The cold, naturally ventilated freestall barn should have: 1) no insulation; 2) an open ridge and sides; and 3) end walls and sidewalls that can be opened completely.

## Water Availability

You should remember that high producing dairy cows can consume between 30 and 50 gallons of water per day. Water should be provided to cows leaving the milking parlor. In parlors that are double 25's or smaller, one trough 8 ft long is usually sufficient. In freestall housing, water should be located at all crossovers, allowing one waterer or 2 ft of tank perimeter for every 10 to 20 cows.

## Number of Crossovers

Crossovers should be provided every 60 to 80 ft, or a row of 15 to 20 stalls. Crossovers are typically 12 ft wide. Oftentimes, producers reduce the number of crossovers in freestall barns to reduce construction costs. This is not a good alternative from the cow's point of view. Reducing the number of crossovers limits access to feed and water. It also reduces the total length available to construct the feedline. Very few producers stock freestall barns at one cow per stall. The tendency is to

overstock freestall facilities. Therefore, cows suffer when the number of crossovers is reduced.

### Groups of Cows

Typically, large dairies have eight strings or groups of milking cows. They also include pens for slow milking cows, mastitis cows, fresh cows, dry cows, and springers. The slow milking pen should have capacity for 2% of the milking cows. The fresh pen and mastitis pen should each have the capacity for 1% of the milking cows. A minimum of two dry cow pens and one pen for springers is usually constructed. Lactating cow pens should be sized so that one group of cows can be milked in 60 min when milking 2x, 45 min when milking 3x, and 30 min when milking 4x.

### Conclusions

Providing comfortable freestall housing is critical in obtaining high milk production. Unfortunately, correctly designing and building freestall facilities is only one part of the equation. Maintaining cow comfort in freestalls is a daily job that requires a lot of dedication and hard work.

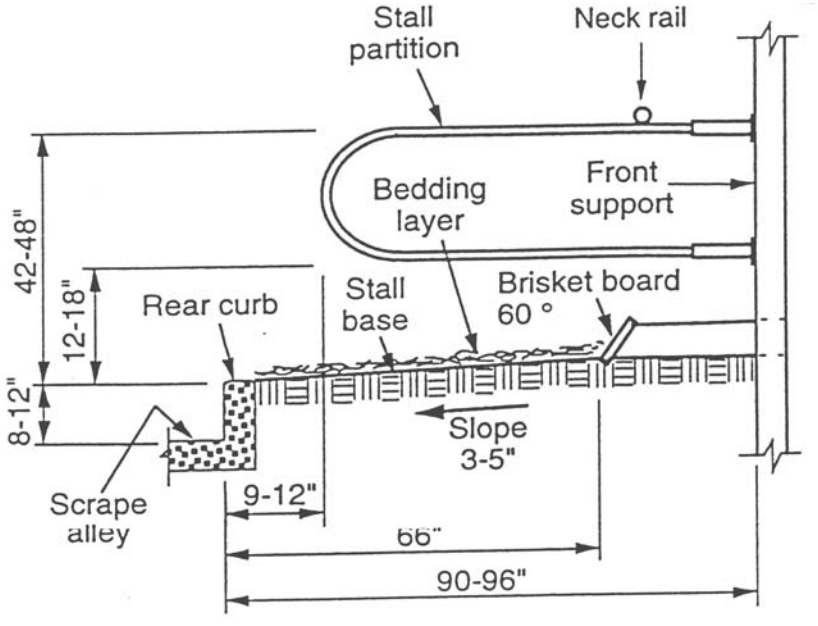


**Figure 1. Freestall Components and Dimensions.**

Source: Dan McFarland, Extension Engineer, and Robert Graves, Professor,
Department of Agricultural and Biological Engineering,
The Pennsylvania State University, University Park

# PLANNING A DAIRY EXPANSION

*J. F. Smith*


## Summary

Dairy farm size is increasing in all regions of the United States. In two of the largest dairy states, California and Wisconsin, mean herd sizes have increased 950% and 250%, respectively, since 1950. Dairy herds of 500 cows are common in all areas of the United States, and herds over 1,500 cows are common in the West and Southeast. Many dairy operations are considering expansion of existing facilities or construction of new facilities to increase efficiency or profitability. Before adding cows or facilities, dairy producers may want to answer the following questions: 1) How can I improve the efficiency of the present operation? 2) Can production per cow be increased? 3) Can the current herd be milked 3× per day? 4) Can I send the heifers to a contract raiser and expand the cow herd? 5) What are my financial goals? 6) Where do I want to be in 5 and 10 years? 7) What are the expectations of other family members? 8) Do I have adequate acreage to expand the herd and manage the waste? 9) Do I want to manage employees? 10) Do I want to deal with regulatory agencies?


(Key Words: Planning, Dairy, Expansion.)

## Introduction

These are just a few of the questions that many producers agonize over when considering options for their dairy operation. This report will help you explore your options and make a decision that will benefit your dairy operation. All options must be considered to make a good decision. Expansion is a three-phase process involving 1) financial evaluation, 2) design, and 3) construction.

## Financial Evaluation

Conducting a financial evaluation is extremely important to determine how realistic an expansion of the dairy operation would be. A Michigan study indicated that 68% of expanded farms experienced cash flow problems for 2 yr; of those, 34% had serious cash flow problems. Results from a second study evaluating productivity in New York dairy farms from 1989 to 1992 indicated that farms that expanded 30% had the highest increases in debt per cow and operating expenses per cow. This group of dairies also had the largest increases in net farm income, return on investment, and milk sold per worker.

Producers desiring to expand need to consider the amount of capital that is available for expansion, the return to the dairy expansion compared with use of equity for other investments, and the cash flow benefits from the expansion. Producers typically are required to contribute 30 to 40% of the expansion cost in some form of equity. They should determine the current cost of production per hundredweight and the marginal revenue per cow, as well as the income from the expanded herd to estimate the amount of debt the expanded herd might carry.

## Designing a New Milking Center

### Design-Build Concept

Many owners and managers who have made the decision to expand prefer to use the design-build concept or a design team. These concepts specify that management employs a dairy design consultant to develop a basic design and program plan to meet the client's needs. The design team consists of an agricultural engineer and supporting dairy management specialists, which could

include dairy extension faculty, nutritionists, milking equipment manufacturers, and veterinarians. This team approach is an efficient way to integrate desired management into physical facilities.

**Parlor Performance**

Performance of milking parlors has been evaluated by time and motion studies to measure steady-state throughput. This does not include time for cleaning the milking system, maintenance of equipment, effects of group changing, and milking the hospital string.

Parlor performance in the U.S. ranged from 25 to 401 cows per hour. Throughput ranged from 84 to 401 cows per hour in parallel parlors and from 60 to 205 cows per hour in herringbone parlors. Performance within a parlor type or size may vary because of construction, milking frequency, detachers, premilking hygiene, and number of operators. The effects of these factors on parlor performance in both remodeled and new facilities are listed below:

- Data collected in parallel milking parlors indicate that milking cows 3× per day versus 2× per day increases throughput by 8 to 10%.
- The use of detachers does not increase throughput with the same number of operators. The use of predip milking hygiene reduces parlor performance by 15 to 20%.
- The average number of cows milked per operator hour decreases as the number of operators increases from 1 to 4.
- Steady-state throughput is 10 to 12% higher in new parlors than in renovated parlors.
- Parlor performance may be decreased by increased milk production per cow.

**Sizing the Milking Parlor**

The milking parlor should be large enough to allow management the flexibility to incorporate premilking hygiene routines. Many large dairies will maximize the number of cows that can be milked through a parlor. In this situation, milking parlors should be sized so that all cows can be milked once in 8 hr when milking 2× per day, once in 6.5 hr when milking 3× per day, and once in 5 hr when milking 4× per day. Using these criteria, the milking parlor will be sized to accommodate cleaning and maintenance. In smaller dairies or diverse operations when the time allowed for milking is limited (6 to 10 hr/day), reducing the number of hours the parlor is used will reduce the return on investment.

Milking parlors need to be designed so that one group can be milked in 30 to 60 min, depending on milking frequency. Observations on commercial dairy farms indicate that a group of cows should be milked in 60 min when milking 2× per day, 45 min when milking 3× per day, and 30 minutes when milking 4× per day to minimize the time cows stand on concrete and the time cows are kept away from feed and to ensure comfortable housing. Group size should be divisible by the number of stalls on one side of the milking parlor to maximize parlor efficiency by having as many stalls as possible per cycle. Typically, size of the milking parlor should be based on the assumption that the parlor can be turned over 4.5 times per hour. The number of cows that will be milked per hour can be calculated using the following formula:

Total no. of stalls × turns per hour = cows milked per hour (CPH)

The number of milking cows can be calculated using the formula below:

no. of milking cows = CPH × shift length (hours)

**Holding Pens**

Holding pens should be designed to allow 15 square ft per cow and to hold at least one group of cows. Many producers oversize them by 25% to allow the second group to be moved into the

holding pen while the first group is still being milked.

**Exit Lanes**

Exit lane width is dependent on the number of stalls on one side of the milking parlor. In parlors with 15 stalls or fewer per side, a clear width of 3 ft is acceptable. For parlors containing more than 15 stalls per side, a clear exit lane width of 5 to 6 ft is preferable.

**Operator Pits**

Operator pits are typically 8 ft wide between curbs. The cow platform is 38 to 40 inches above the floor of the operator pit. Provisions should be made to allow for floor mat thickness, if mats are to be used. The curb of the cow platform typically overhangs the operator pit wall by 9 inches. Normally, the operator pit and cow platform should have a 1% slope to the rear of the milking parlor. Operator pits typically have 2 inches of side slope from the center of the pit to the pit walls.

**Constructing the Milking Parlor Shell**

Several options are available for constructing the shell of the milking parlor. If no future expansion is planned, the building can be constructed with no room for expansion. This often is done in situations in which acreage is not sufficient for expansion. When long-term plans include expansion, the shell can be constructed with room to add a second parlor or add stalls to the existing parlor. If a second parlor is to be added at a later date, usually the two parlors would share a common equipment and milk storage facility. If additional stalls will be added to a parlor, space should be left in the front of the parlor to reduce cow entry time. The holding pen should be sized for the total number of cows that will be milked after the expansion. The milking facility should be ventilated properly to maintain employee and cow comfort. Office, meeting room, break room, and rest room facilities should be incorporated to meet the needs of management.

**Renovating a Parlor**

Another option is to renovate an existing milking parlor, provided acreage is sufficient for additional pens and waste management needs. If an existing milking parlor is to be updated to include these activities, appropriate measures must be taken to ensure that the waste management system can handle any expected increase in waste water flows. Storage ponds must be evaluated to ensure that adequate waste water storage is available. Finally, the acreage available for manure and effluent application must be evaluated to determine how many cows can be accommodated in the facility.

Often, a herringbone parlor is converted to a parallel or parabone parlor to increase the number of stalls without increasing building size. The distance between the front of the stalls to the wall of the parlor should be a minimum of 6 ft to take advantage of rapid exit stalls. If a standard exit is used, the number of cows milked per hour will be reduced by the number of stalls on one side of the parlor. Often, exit lane width is too narrow, slowing down cow exit from the parlor. The holding pen usually needs to be expanded when a parlor is remodeled. The refrigeration system and milk storage may need to be increased to compensate for additional milk production. The vacuum system also may need to be upgraded.

## Selecting Cow Housing

Selecting the type of housing is an important decision that should be made with the lactating cow in mind. Several of the new large dairies in southwest Kansas have built drylot facilities versus freestalls. The climate in northeast Kansas does not allow the option of building a drylot facility to house lactating dairy cows. However, various configurations of freestall barns will work. My preference is to build a 2-row or 4-row freestall barn. I would be concerned about the level of heat stress and the limited feeding area in 6-row freestall barns. Producers building 6-row barns may want to seriously consider mechanically ventilating them. It is essential that freestall barns are ventilated properly and the stall dimensions are correct. Figure 1 shows the recommended dimensions for freestalls. Freestall housing should be constructed to pro-

vide good natural ventilation. Sidewalls should be 12 to 14 ft high to increase the volume of air in the housing area. The sidewalls should be able to open a minimum of 50% and preferably 75 to 100%. Fresh air should be introduced at the cow's level. Curtains on the sides of freestall barns allow management greater flexibility in controlling the environment around the cow. Because warm air rises, steeper sloped roofs provide upward flow of warm air. Roof slopes for freestall housing should range from 4/12 to 6/12. Roofs with slopes less than 4/12 may have condensation and higher internal temperatures in the summer. Providing openings in addition to alley doors on the end walls will improve summer ventilation. Gable buildings should have a continuous ridge opening to allow warm air to escape. The ridge opening should be 2 inches for each 10 ft of building width. Naturally ventilated buildings should have a minimum of 50 ft between structures.

In the Midwest, freestall barns typically are oriented east to west to take advantage of sun angles and provide afternoon shade. Producers who orient barns north to south will have to construct an overhang on the west side adequate to shade stalls in the afternoon. Freestall barns should be located as close to the milking center as possible without restricting ventilation. The goal is to reduce the distance cows have to walk to and from the milking parlor. Field observations indicate that distance from the gate of the housing area to the gate of the holding pen should be a maximum of 1200 ft for 2× milking, 900 ft for 3× milking, and 700 ft for 4× milking.

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You should remember that high producing dairy cows can consume between 30 to 50 gallons of water per day. Water should be provided to cows leaving the milking parlor. In parlors that are double 25's or smaller, one trough 8 ft long is usually sufficient. In freestall housing, water should be located at all crossovers, allowing one waterer or 2 ft of tank perimeter for 10 to 20 cows.

**Number of Crossovers**

Crossovers should be provided every 60 to 80 ft, or a row of 15 to 20 stalls. Crossovers are typically 10 to 12 ft wide. Oftentimes, producers reduce the number of crossovers in freestall barns to reduce construction costs. This is not a good alternative from a cow's point of view. Reducing the number of crossovers limits the cow's access to feed and water. It also reduces the total length available to construct the feedline. Very few producers stock freestall barns at one cow per stall. The tendency is to overstock freestall facilities. Therefore, cows suffer when the number of crossovers is reduced.

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Typically, large dairies would have eight strings or groups of milking cows. They also would include pens for slow milking cows, mastitis cows, fresh cows, dry cows, and springers. The slow milking pen should have capacity for 2% of the milking cows. The fresh pen and mastitis pen should each have the capacity for 1% of the milking cows. A minimum of two dry cow pens and one pen for springers usually is constructed.

## Construction

Construction of a new facility or remodeling of an existing facility is a time-consuming process. In general, a minimum of 4 to 6 months is needed to construct a new facility. Because managers want to generate income as soon as possible, cows often are ready to calve before the milking center is complete. Adequate time should be allowed for construction delays because of weather and other uncontrollable variables.

Dairy producers remodeling an existing barn need to consider how cows will be milked during renovation. Options include: leasing an alternative facility; constructing temporary facilities; moving cows to another dairy during the construction; or remodeling one side of the parlor, while milking cows on the other. Everything possible should be done to minimize stress on the cows during this process and prevent losses in milk production.

## Increasing Cow Numbers

Producers should strive to increase lactating cow numbers as soon as the facilities are completed. Realistic goals should be set to purchase the cows and move them into the new facility. Establishing milk flow as soon as possible is desirable; however, many producers have struggled with heifers calving before the new facility is complete. Producers should work with their veterinarian to minimize the risk of bringing infectious diseases into the herd. Purchasing heifers versus cows will minimize the risk of inheriting another herd's mastitis problem.

Producers who aggressively purchase heifers often underestimate the facilities and labor required when a large number of animals calve in a short period of time.

## Summary

Expansion is a drawn out and sometimes tedious process. However, dairy expansions have been rewarding for many producers. Evaluating all your options is important. The guidelines in this report are benchmarks to help you get started and may have to be modified when applied to your dairy operation. Good luck in your future plans!

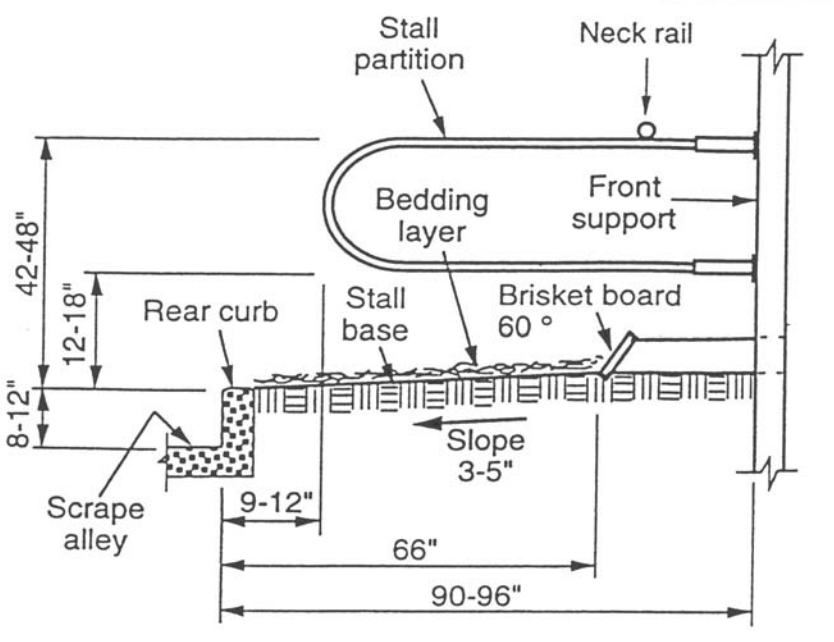


**Figure 1. Freestall Components and Dimensions.**

Source: Dan McFarland, Extension Engineer, and Robert Graves, Professor, Department of Agricultural and Biological Engineering, The Pennsylvania State University, University Park

# BIOSECURITY IN THE DAIRY

*G. L. Stokka, T. R. Falkner, and P. Bierman*


## Summary

Three strategies exist to control unwanted disease in a livestock operation: 1) prevent the introduction of infected cattle, 2) raise the overall level of resistance and specific resistance to infectious disease, and 3) minimize herd exposure to infectious disease. In addition, if unwanted disease exists in the herd, then a plan to eliminate the disease should be implemented. Maintenance of closed herds, testing procedures, vaccination schedules, sanitation, and good husbandry practices are integral parts of biosecurity procedures. The procedures in place should produce a benefit in terms of both economics and public perception that the quality and safety of our food supply is of the utmost importance to livestock producers.

Livestock units exist for the purpose of producing a nutritious food product, which is accomplished through the use of forages and cereal grains. This system benefits the producer by adding value to renewable resources. Society benefits through the availability of a wholesome, safe, food supply in addition to the creation of new wealth within our economic system. The time has come for the food production industry, especially the dairy and beef sectors, to recognize the benefits of biosecurity procedures. Those of us involved in the food production business must always keep in mind the importance of maintaining healthy animals and a healthy food supply.


(Key Words: Biosecurity, Disease, Management.)

## Introduction

In the dairy industry, measurements of the cost of disease are quite sensitive. Each doubling of the somatic cell count above 50,000 is estimated to cost as much as 400 lb per lactation in mature cows. Any clinical disease or even subclinical disease will result in a cost to the operation. In addition, some disease incidents may pose a risk to herdmates as well as a zoonotic risk to producers and a foodborne risk to the public.

Three strategies can prevent disease from entering or occurring in a livestock production unit. The first is preventing the introduction of infected cattle. This approach begins by ensuring that cattle are purchased from uninfected herds or herds with known health status, which implies an effective vaccination program. Never purchase cattle from unknown sources or from commingled sources. Purchased cattle should be isolated and monitored for 30 days before entering the herd. If necessary, test new herd additions for infectious disease, such as brucellosis, Johne's, BVD, and bovine leukosis, before introduction to the herd. Recipients used for embryo transfer also can be sources of disease and should be tested as necessary. If young calves are purchased, they should be from a reputable source and tested as necessary, particularly for persistent infection with BVD viruses. Purchased animals should be transported in clean and disinfected trailers or trucks.

The second is raising the overall level of resistance and specific resistance to infectious disease. Reducing environmental stress can increase the overall level of resistance. Provide clean dry bedding and comfortable housing to all

animals and use shades during the summer and windbreaks during the winter. Reduce nutritional stress through proper transition diets and balanced lactation rations. Colostral management is the most important factor for increasing the overall resistance in newborn calves.

The third is minimizing herd exposure to infectious disease. Limit exposure of the dairy facilities to outside people. Require your veterinarian and other professionals to use sanitary practices (e.g., sanitize equipment, use clean boots and coveralls). Reduce manure contamination of feed bunks, water sources, feed, and feeding equipment. Utilize cattle loading facilities away from the main animal facilities to minimize exposure to buyers and transportation equipment. Raise calves in individual hutches that are disinfected between uses. Sick animals should be isolated in most instances, particularly in unusual cases or when the response to treatment is unfavorable. Animals that die should be necropsied, either to identify the cause of death or to confirm the diagnosis. Necropsied animals must be disposed of properly, either via the renderer or burning and burying.

Elimination of disease when present in a herd is almost always more expensive and difficult than prevention. For some diseases such as leptospirosis, eliminating or effectively keeping animals from exposure may be impossible. Other diseases require a long-term and disciplined plan for reduction and elimination. For some diseases, elimination may involve total depopulation. Elimination of certain diseases requires active monitoring and action plans to handle each case as it occurs.

The following sections provide short description of diseases of importance to dairy herds and suggestions for prevention, treatment, and elimination.

## Bovine Virus Diarrhea

Bovine virus diarrhea (BVD) is one of the most significant viral infections of cattle. BVD was first recognized as a disease syndrome in 1946, and today 70-90% of the world's cattle population is seropositive for BVD. The BVD virus (BVDV) has at least two genotypes, type 1 and type 2, and two biotypes, cytopathic and noncytopathic. Both type 1 and type 2 genotypes have cytopathic and noncytopathic biotypes as members, and both type 1 and type 2 genotypes have many different strains, some of which are more deadly than others. Recently, the type 2 genotype has caused many of the most severe cases of BVD.

### Clinical Syndromes

Most BVDV infections are subclinical, but the clinical disease syndromes can be grouped into three categories: acute BVD, *in utero* infections, and diseases in persistently infected (PI) animals.

Acute BVD can vary greatly in presentation from fever, depression, and runny nose and eyes to diarrhea to respiratory disease and can end in complete recovery or death depending on several factors. These include the immune status of the animal, strain with which they are infected, and age of the animal. BVDV has a profound immunosuppressive effect on infected cattle. Infected cattle are more susceptible to many respiratory and intestinal pathogens. BVDV is also an important component of bovine respiratory disease complex (BRDC).

*In utero* infections with BVDV can result in abortion; PI animals; congenital defects; or normal, immune-tolerant calves, depending on the stage of gestation and the cow's immune status when she is infected with the virus. The noncytopathic biotype is responsible for all *in utero* infections. If a cow is infected with BVDV in the first trimester of pregnancy, the fetus will most likely die, and the cow may reabsorb the fetus, abort, or give birth to a mummified fetus. The abortions are usually sporadic and at a low rate, usually only 2-7% in an outbreak. If the cow is infected with BVDV between 60 and 120 days of gestation, the calf may be PI. These animals are lifelong carriers of BVDV and shed large quantities of virus in all secretions throughout their entire lives. The immune system in calves less than 120 days of gestation is not capable of responding properly to BVDV, so the virus simply multiplies in the

calf. When the immune system becomes competent, the virus is recognized as "self", and the calf is "immune tolerant" to that strain of BVDV for life; that is, it never develops an immune response to that strain. Infection with BVDV between 100 and 180 days in gestation can result in congenital defects such as cerebellar hypoplasia, hydrocephaly, cataracts, and other similar defects. Infection of the dam in the last trimester of gestation, when the calf's immune system is functional, will yield a normal, immunized calf.

Persistently infected animals can result from *in utero* infection as described above or by being born to a PI dam. The prevalence of these animals in cattle herds is low (.5-3%), but their potential to shed large quantities of virus and infect other animals in the herd is tremendous. Persistently infected cows always give birth to infected calves, and seronegative cows (cows that have not mounted an immune response to BVDV) are much more likely to give birth to infected calves. However, some seropositive cows can give birth to infected calves, if their circulating antibodies do not cross-react with the virus to which they are exposed. Persistently infected calves are often "poor doers" and are more susceptible to other calfhood diseases because of the immunosuppressive effects of BVDV. Sometimes, however, infected calves may look perfectly normal and healthy. Persistently infected calves reportedly have death rates of 50% in the first 12 months of life. Some of these probably die from other calfhood diseases as well, but many die from BVD-mucosal disease (BVD-MD). BVD-MD occurs when PI animals that harbor noncytopathic BVDV are exposed to a cytopathic variant probably through mutation of the noncytopathic strain to a cytopathic strain. BVD-MD is characterized by profuse diarrhea with severe erosions and ulcers on all mucosal surfaces. It occurs most often in cattle 6 to 24 months of age and is nearly 100% fatal.

**Transmission**

BVDV rapidly loses infectivity outside the host and is very susceptible to detergents, light, temperature changes, and other environmental conditions. It is mainly transmitted by close contact with PI or acutely infected cattle via the oral or nasal routes. Acutely infected animals shed the virus only for a short time (about 2 wk), whereas PI animals shed constantly in all bodily secretions for life. Acutely infected bulls shed virus in their semen for at least 2 wk, and PI bulls shed virus constantly in their semen. Thus, semen is another potential source of infection during natural mating. Reputable A.I. studs will check their bulls and semen for BVDV. Sheep, goats, and pigs can become infected from close contact with cattle, and sheep can transmit the virus to cattle in close contact. Needles, rectal sleeves, water troughs, feed bunks, nose tongs, and other equipment can aid the spread of virus. Experiments have shown that biting insects also spread the virus.

**Diagnosis**

Diagnosis of BVD is accomplished by observation of clinical signs, serology, virus isolation, fluorescent antibody, or polymerase chain reaction (PCR) tests. The virus can be isolated from nasal swabs, serum, or tissue depending on the disease syndrome present. Diagnosis of BVD-MD is very important, because if BVD-MD animals are found, the herd should be screened for more persistently infected animals.

**Prevention**

Adding PI animals to a herd should be avoided, because that is the most common way to introduce BVDV into a herd. Replacement animals should be purchased from herds with accurate records of disease and vaccination. All new animals, or at least any small group of new animals, such as bulls, should be isolated and tested for BVDV before entering the herd. Semen should be from tested bulls only. If embryo transfer work is performed, all recipients

should be isolated, tested for acute or persistently BVDV infection, and vaccinated against BVDV.

Vaccination programs are essential to decrease losses to BVD. The goal of any vaccination program is to prevent fetal infection and increase colostral immunity. This may not always work, depending on the strain of vaccine and the field strain, but it is the best weapon we have. Vaccination does not clear persistent infections from a herd, but the virus doesn't spread as quickly through a vaccinated herd.

Two types of vaccine available include the modified live and inactivated (killed) forms. Much controversy exists over which is better. Modified live vaccines (MLVs) offer more cross-protection against different strains, and the immunity conferred by them is longer lasting and stronger. Modified live vaccines should be used with caution, however, because they can cause immunosuppression or fetal infection or revert to virulence. Inactivated vaccines are not immunosuppressive, do not infect fetuses, and have minimal risk. However, the immune response they generate is weaker, of shorter duration, and may not cross-protect as well as MLVs. Cattle receiving inactivated vaccine also must have a booster 3 to 4 wk after the first vaccination. Neither MLVs nor inactivated vaccines give lifelong protection, and yearly boosters are required with both.

No one vaccination program works for all situations. Producers should consult their veterinarian for a program tailored for their herd. Here are a few options.

For replacement heifers (separated from pregnant cows), use an MLV at 6 months of age and again 60 days before breeding or use an inactivated vaccine 5 wk before breeding and again 2 wk before breeding.

For cows, use inactivated vaccine 2 wk before breeding or use MLV before breeding. Either of these options can be used with either option for heifers.

Vaccinate calves with a different strain of inactivated vaccine than used for cows 3 to 4 wk before weaning or vaccinate with MLV before weaning.

**Control**

If a diagnosis of BVD is made in a herd and significant losses are occurring, control measures may need to be taken to decrease future economic losses. Vaccination will slow the spread through the herd but will not prevent PI animals from shedding virus. They must be removed from the herd. Several procedures have been outlined to screen the herd for PI animals. One option for complete herd screening is to collect serum from every animal in the herd and analyze it with the microplate virus isolation test, and then remove all animals that test positive. This test is very sensitive and specific for BVDV. Another option is to perform serology on every animal in the herd and cull those animals with very low or absent titers. This can be performed only in herds that are vaccinated or have active BVDV circulating and is not as sensitive for detecting PI animals as the microplate test. Some researchers recommend testing only the calves with microplate virus isolation and then testing only the dams of the calves that test positive. A common theme in these procedures is that all calves born for the next 9 months also must be tested to ensure that no new PI animals are born into the herd. With any screening procedure, biosecurity measures as outlined in the "Prevention" section must be implemented to prevent reintroduction of PI animals.

## Neosporosis

*Neospora caninum* is a coccidian protozoa that originally was found in dogs but later found to be a major cause of abortion in cattle, sheep, goats, and horses. The complete life cycle is not known, which makes formulation of control programs difficult. We assume that some definitive host sheds oocysts in its feces; however, most cows are infected congenitally, which is the only known natural route of infection. Abortion is the only clinical sign in *Neospora* infected cows, and multiple abortions can occur over a few months. Most abortions are at 4-6 months of gestation but can occur any time between 3-8 months of gestation. Calves infected congenitally can be underweight, weak,

unable to rise, uncoordinated, or normal. Most cases of neosporosis have been associated with dairy cattle, but congenital infections and abortions also have been documented in beef cattle.

Diagnosis of neosporosis is difficult in live cattle but can be accomplished in aborted fetuses by a combination of immunohistochemistry on the tissues and serology from the dam. Aborted fetuses and placentas should be handled with caution, because there is a real possibility that this parasite can infect humans, although it has not been proven yet.

Prevention programs are difficult to design because of the lack of knowledge of the life cycle. No vaccines or drugs are available for treatment. Aborted fetuses and placentas should be burned or otherwise properly disposed of to prevent the potential intermediate host or other cows from being infected by eating these tissues. Feed and water should be protected from fecal contamination by domestic or wild animals. Infection of the cow before or during pregnancy can cause abortion, but not all infections result in abortion. Seropositive cows are two times more likely to abort from neosporosis, and cows that abort once from neosporosis can abort again from the disease.

If abortions from neosporosis are high in number, control measures may need to be taken. Many control programs exist. One possible first step is to screen 35-50 cows, depending on herd size, with serology (ELISA or IFA) to find the prevalence of *Neospora* in the herd. If the prevalence is low, the entire herd can be screened, and the seropositive animals culled. If the prevalence is too high to cull out the seropositives, one possibility is to test all dams and daughters of cows that have aborted and cull the seropositives. Also, testing replacement animals and permitting only seronegative replacements to enter the herd will reduce congenital infections. If embryo transfer is done, use only seronegative recipients, and don't purchase a heifer whose recipient was seropositive.

*Neospora* is a major cause of abortions in cattle. Prevention and control are complicated by the unknown life cycle of the parasite. Diagnosis is difficult in live cows, but antibodies can be detected to help point out cattle at higher risk of aborting. Testing all new animals before they enter the herd and protecting feed and water from contamination by other animals are keys to prevention.

## Cryptosporidiosis

*Cryptosporidium parvum*, also known as "Crypto", is a protozoan parasite closely related to coccidia. It is present in virtually all calf-raising environments and can cause calf diarrhea. It can infect all mammals, including humans, in which it causes severe headaches, vomiting, nausea, and weakness in addition to severe diarrhea. In elderly and otherwise immunosuppressed people, it can be life threatening. The organism commonly infects calves 1 to 4 weeks of age, causing a nonbloody, yellow, watery malabsorbtive diarrhea that is usually self-limiting, and mortality is low. Diagnosis can be made by fecal flotation or fecal smear stained with acid-fast stain.

Infected calves shed billions of infective oocysts in their feces, and adult cattle can shed some as well, but far fewer than calves. Transmission from calf to calf or calf to human is primarily by the fecal-oral route, although it can be transmitted by the aerosol route as well. The most common place for calves to become infected is in the calf-rearing area. Control of "Crypto" focuses mainly on management. The organism is hardy and has been shown to survive from 2 to 6 months at 4°C (40°). The organism is resistant to most disinfectants, but bleach at half strength is effective, as is formalin (formaldehyde). Formalin is very toxic and should be used only under strict supervision. Putting calves in hutches or on a clean pasture with low stocking density will reduce the level of exposure to *C. parvum*, and thereby reduce losses from "Crypto" diarrhea.

If calves become ill with "Crypto" diarrhea, the only treatment is supportive care, especially electrolyte and fluid therapy. The use of anticoccidial drugs has been suggested for treatment and prevention but has not proven to be effective.

### *Salmonella* Infections

Many species of the bacterium *Salmonella* affect cattle. They can cause sporadic abortions and, more commonly, neonatal diarrhea, especially in dairy calves. They are not common causes of diarrhea in beef calves. Humans can be infected with *Salmonella* by drinking unpasteurized milk or handling infected placentas and fetuses. Most cattle become infected by ingestion of contaminated feed, water, or milk. *Salmonella* can be shed by asymptomatic carrier cows and calves, and it can survive in a damp environment for months. Rodents can also be a source of the bacterium.

Good hygiene is essential to halt the continued spread of *Salmonella*. The calving area should be clean, and hutches should be used. The hutches should be cleaned and disinfected after each group of calves, and the feeding utensils should be cleaned between feedings. A rodent control program should be instituted. All replacements should be tested to be sure they are not carriers, and aborting animals should be isolated. Vaccinating cows with two doses of a killed bacterin may help control *Salmonella* in calves less than 3 weeks of age, but vaccination of the calves is usually not protective. Good hygiene, not vaccination, should be the main focus for controlling *Salmonella* diarrhea.

### Johne's Disease

Johne's disease, also known as paratuberculosis, is caused by *Mycobacterium paratuberculosis*, a slow growing bacterium that can survive in the environment for approximately 1 year. It is best known in the dairy industry, where it costs U.S. dairy producers an estimated $1.5 billion annually, but cases in beef herds, especially seedstock operations, can be devastating as well. In addition to death loss, premature culling, and decreased weight at slaughter, losses from decreased milk production and increased susceptibility to other diseases such as mastitis can be major. Johne's disease is a reportable disease in Kansas. Recently, *M. paratuberculosis* has been associated with Crohn's disease in people, but scientific evidence is not available to prove or disprove its involvement in the disease at this point.

Most cattle with Johne's disease were infected as young calves, which are most susceptible. Calves have no clinical signs, and, therefore, this stage of the disease has been called the "silent" stage. After an incubation period of 2-10 years, infected adult cows can be more prone to mastitis or infertility. These animals can be shedding the organism in their feces at undetectable levels, which can contaminate the environment. Within a few weeks, clinical signs such as gradual weight loss with a normal appetite, diarrhea, and decreased milk production can appear. In advanced cases, animals are very weak, have profuse, "pipestream" diarrhea, and can have intermandibular edema, or "bottle jaw", and death follows shortly. For every such case of advanced Johne's disease on a farm, 15 or 25 other animals likely are infected.

The major route of infection of calves is ingestion of colostrum and/or milk contaminated with fecal material. Calves also can be infected *in utero*, especially if their dam is clinically ill. Such infection is unlikely in early, subclinically infected dams. Infected cows can shed the organism directly in colostrum or milk as well, which is another potential source of infection for calves. Adults can be infected from contaminated feed, but they are less susceptible than calves, and because of the long incubation time, likely will be culled before they shed the organism. The organism also can be transmitted by semen, in uterine fluids, by rectal examinations, and by wildlife, but these are not likely sources of infection. Embryo transfer and artificial insemination are not likely sources of infection because of frequent testing. However, all embryo transfer recipient cows should be tested, because fetal infection can occur transplacentally.

## Prevention

Because of the nature of the disease, prevention is much more economical than control once it has entered the herd. Herds are infected primarily by purchasing infected animals. These animals may show no clinical signs for many years and may even test negative on serologic and fecal culture tests. The sensitivity of tests for Johne's disease is only about 50%, which means 50% of animals with the disease will not test positive. Therefore, it is best to maintain a closed herd or purchase replacements from herds that are certified to test negative. If this is not possible, prepurchase testing of the seller's entire herd should be done. If none or very few test positive, chances are very good the animals purchased are not infected. At the minimum, replacements should be purchased from reputable herds with no clinical history of Johne's. All new animals should be isolated and tested before they enter the herd. The risk of bringing in paratuberculosis in an animal from a sale barn has been estimated at 10% per animal. Another preventative measure that should be practiced on all farms is proper cleaning of calving areas and calf hutches.

Many tests are available to test individual animals and screen herds for Johne's disease. The sensitivity of these tests for early detection is low because of the slow progression of the disease. Fecal culture is best for detection of infected animals in a herd. It is 100% specific, which means every positive test truly indicates an infected animal, and 50% sensitive. The major drawback to this test is the 12- to 16-wk incubation period before results are available. A new culture method is available that has only a 4- to 7-wk incubation period, but it is more expensive. Three serum tests that detect antibodies to paratuberculosis are used commonly. They are the complement fixation test (CF), the agar gel immunodiffusion test (AGID), and the enzyme-linked immunosorbent assay (ELISA). Results from these tests are available in 2 to 4 days, and they are nearly 100% specific and quite sensitive in detecting infected animals, especially those with clinical signs. ELISA has a sensitivity of 99% and a specificity of 15 to 87%, depending on the stage of the disease, but overall specificity of 45%. It is the most sensitive and specific of the serum tests. A DNA probe test, which is fast but expensive and less sensitive than fecal culture, also is available. Rectal scrapings or histopathology of tissues are both sensitive in detecting clinically ill animals. The newest test method, which tests for cellular immunity, is not proven yet, but has a promising future. The Johnin Test, which has been used in the past, is no longer recommended.

## Control

Control and/or eradication of Johne's disease on a farm that has had confirmed cases of the disease is a long, difficult process and should be undertaken only if management changes can be instituted. No "cookbook" method of control works for every farm, but a summary of key points follows. Control programs have two fundamental objectives. The first is to prevent highly susceptible newborn calves and young animals from ingesting manure, colostrum, and milk from infected cows. To accomplish this, remove the calves early; put them in hutches; and feed them only uninfected colostrum, milk, or milk replacer. Improving hygiene to reduce exposure of calves to *M. paratuberculosis* also reduces exposure to *Salmonella*, *E. coli*, Crypto, and coccidia because of decreased fecal contact. The second objective is to reduce total farm environmental contamination by culling infected animals. To accomplish this objective, screen all animals over 20 months of age with the ELISA test or fecal culture, and cull all animals that test positive. A more aggressive strategy is to cull all offspring from cows that test positive, because of the possibility they were infected *in utero*. The ELISA test is recommended for the first screening, because it is the least expensive test with similar sensitivity and specificity to fecal culture. Within 1 year after the test-positive cattle have been culled, all animals over 20 months of age should be tested again, with either ELISA or fecal culture, and the test-positive animals culled. Herd screening should continue, but the time between screenings varies depending on multiple factors. Elimination of Johne's disease takes many years, and biosecurity measures as outlined above should be practiced along with the control program.

A killed vaccine is available for use by accredited veterinarians, usually under the supervision of the state veterinarian, and its usage varies from state to state. It does not prevent infection, but it does delay the onset of clinical signs. However, it interferes with diagnostic tests for Johne's disease and is not recommended.

## Mastitis

Mastitis is inflammation of the mammary gland. The majority of mastitis causes are caused either by contagious mastitis pathogens such as *Streptococcus agalactiae* and *Staphylococcus aureus* or environmental pathogens such as *Escherichia coli* and *Klebsiella pneumonia*. Mastitis also can be caused by other organisms such as *Nocardia* sp. and yeast.

Environmental mastitis is caused by pathogens present in feces, bedding, or other places in the cow's environment. They are impossible to eliminate, so steps to prevent environmental mastitis include decreasing exposure of teat ends to pathogens and increasing the resistance of cows to intramammary infections. Conditions that increase exposure to environmental pathogens include overcrowding; elevated temperature and humidity in barns; poor ventilation; accumulation of manure, urine, and water; poor stall design; access to ponds or muddy lots; and dirty maternity stalls or calving areas. To increase the resistance of cows to intramammary infections with environmental pathogens, they should be fed a well-balanced diet that is sufficient in vitamin E and selenium. The J-5 bacterin-toxoid has proven effective in decreasing incidence and severity of these infections as well.

Contagious mastitis is transmitted from cow to cow via infected milk at milking time through the milker's hands, milking units, common sponges and towels, and other items used during milking. Most *Strep. agalactiae* and some *S. aureus* infections respond to most commercial intramammary antibiotic products in both the lactating and dry periods. Chronic *S. aureus* and *Strep. agalactiae* infections may not respond to antibiotic therapy, and chronically infected cows should be identified, segregated, and milked last at every milking. They should be culled when daily feed costs exceed income from milk production. Prevention and control or eradication of *S. aureus* and *Strep. agalactiae* infections can be accomplished by good milking practices, especially proper udder preparation using single-use towels and post-milking teat dips. Also, purchase animals from herds with low somatic cell counts and test individual animals before they enter the milking herd. New animals should be milked last until negative test results for contagious mastitis are returned.

Cases of *Nocardia* sp. and yeast mastitis often are due to contaminated mastitis treatment preparations and infusion needles. Yeast mastitis also can result from multiple antibiotic treatments, because yeast are resistant to antibiotics.

## Hairy Heel Warts

Papillomatous digital dermatitis, also known as hairy heel warts, is a contagious infection of the skin, usually on the back of the foot between the bulbs of the heel, most often on the rear feet. It is primarily a disease of housed dairy cattle and rarely occurs in pasture cattle. Unlike true bovine warts, which are caused by a virus, heel warts are most likely caused by spirochetes, which are spiral-shaped bacteria. Early heel warts can be flat and circular and later become raised masses and develop hair-like projections. They bleed easily if traumatized and can cause severe pain and lameness, resulting in economic losses from decreased milk production, decreased reproductive efficiency, and cost of treatment. Only about 50% of cows with heel warts are actually lame, which makes control difficult.

Introduction of the bacteria into a clean herd may be difficult to prevent in anything but a closed herd, but isolation of replacement animals for at least 1 month and checking all their feet very closely before introducing them into the herd are good practices. Also, hoof trimmers, veterinarians, and any other visitors should clean and disinfect their boots and equipment before working on the herd.

Once introduced, the warts spread quickly through the herd, and eradication is difficult or impossible because of the subclinical cases and lack of immune clearance. Lactating heifers and

young cows may show more lameness than older cows, but this pattern does not always hold true.

Treatment of heel warts is by extra-label drug use, so your veterinarian must be consulted for a treatment protocol. Whole-herd treatment is necessary to control heel warts, because of the high incidence of subclinical cases that can perpetuate the problem in the herd and the propensity of the warts to recur. The most cost-effective method of whole-herd treatment is by topical spray of antibiotics, such as tetracycline, after washing the feet. Foot baths are effective only if properly prepared and maintained, which can be very expensive. Whole-herd treatment is not a cure and will have to be repeated on a regular basis to limit the incidence of this disease in the herd.

# FLUSHING MANURE SYSTEMS FOR DAIRY FACILITIES

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## Summary

Flushing systems that collect and transport manure are utilized in dairy operations. The sanitation attainable and reduced labor requirements can make flushing a desirable option. Designed flush systems utilize a flush device to release the correct volume of water at the appropriate discharge rate and length of time. This achieves the designed flow velocity, contact time, and depth of water in the gutter to obtain adequate cleaning.


(Key Words: Flushing, Manure, Separator, Lagoon.)

## Introduction

Flushing dairy manure is an alternative to blade scraping of freestalls or holding pens. It offers the advantages of labor reduction with automated systems, limited scraping requirements, lower operating cost, drier floors, potential reduction in odor and cleaner facilities. However, an optional method of handling the manure is necessary in colder weather, and scraping may be required. Other disadvantages include the water requirements per cow and the initial fixed cost. A flush system consist of three areas: a high volume flush mechanism, a channel for directional control of the flush water, and the collection of flush water for separation of the liquid and solid. Flushing does not eliminate the need to apply the manure and effluent to land in amounts based on crop utilization.

## Design Parameters

Daily water requirements for flushing vary depending on the width, length, and slope of the area to be flushed. Computer simulations show that slope of the building and flush water velocity have the greatest impact on cleaning efficiency. Buildings with alleys sloping 2 to 4% will use significantly less water per day for flushing as compared to alleys at a 1% slope (Tables 1, 2, 3). At an optimal slope of 3%, a minimum flush volume is 100 gal per ft of gutter width for flushing lengths of less than 150 ft. Longer lengths require more water, with a suggested maximum release of 175 gal per ft. A study of six dairies found flush water requirements ranging from 240 to 620 gal per cow per day. Another design procedure suggests selecting the larger of two volumes -either 52 gal per cow per flush or 1.35 gal per sq ft of alley per flush. Normally, recycled water from the lagoon is used for flushing the freestalls, and fresh water is used for flushing the milk parlor and holding pen.

The cleaning efficiency of a flush system depends on the energy of flush water to remove the manure away from the alleys or pens. Most data available are from observation of installed systems rather than optimized design through computer simulations. Present design procedures suggest that the flushing wave needs to be 150 ft in length and 3 in deep and moving at a velocity of 5 fps. Buildings longer than 450 ft require the flush wave to be at least 1/3 of the total length. If the length is less than 150 ft,

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then the design procedures are based on a 10 sec contact time. The amount of time flush water moves past a given selection of the alley is known as contact time. Observation indicates that a contact time of at least 10 sec improves cleaning efficiency. Minimum design values are a flush velocity of 3 fps and a contact time of 5 sec.

### System Components

Selection of how flush water is released at the upper end is critical. The two basic methods for flushing use storage structures and pumps. Storage structures have the flush water stored in a tank or tower at the upper end of the area being flushed. A low hp pump is used to transfer water from the lagoon to the storage tank. Flushing tanks have larger discharge openings and a typical depth of 8 to 12 ft. Towers discharge through 12- to 24-in diameter pipe and have depths of 20 ft or more. Types of flush-water storage structures include siphon tanks and gravity flow tanks or towers. These tanks may be either round or square, and towers generally are round. Flushing pumps utilize the lagoon for storing the flush water. A large hp pump then pumps the water to the upper end when flushing is desired.

Tables 1, 2, and 3 provide summaries of volume of water and discharge (release) rate required to meet the recommended design requirements for buildings with different slopes, lengths, and alley widths of 10, 12, and 14 ft, respectively. The time a valve is open is determined by dividing the volume of water required by the release rate. With storage units, the release rate varies from a minimum of 10 sec to more than 60 sec for longer buildings. Release rates can vary from 1,000 gpm to over 15,000 gpm if properly designed. Flush-water pumping systems often are limited by the pump capacity, and the water release rate is 60 sec or longer. Most of the pumping systems are limited to a release rate of less than 2,000 gpm. Higher release volumes require larger hp pumps and transfer pipes. Flush storage structures use less water and depend upon the velocity to move the material the length of the gutter. Flush pumps use higher volumes of water at lower velocities. The material is moved in smaller quantities rather than "en masse" as with the storage structure system.

The channel for controlling the flushing water is normally the freestall alley or holding pen. Flushing dairy facilities is different than flushing swine facilities. Flushing channels in swine buildings range in width from 8 to 12 ft with secondary channel dividers located 3 to 4 ft on center. These secondary channels provide directional control of the flush water as it moves the length of the building. Swine facilities can be flushed year round, because the buildings are warmer. Channels for dairy facilities range from 8 ft to 14 ft in a freestall and up to 40 ft wide in a holding pen. Secondary channel dividers are not used because of vehicle and animal traffic. The flush is dependent on the uniformity of the floor surface. The alley may need scraping in cold weather. Some scraping or manual cleaning along the freestall curb also may be needed, because much of the manure is deposited there. Some try to avoid this cleaning by placing a pipe along the top of the curb to prevent the manure from being deposited against it. Others place a 3/4 to 1 in crown in the alley to direct more flush water along the curbs, if freestalls are along both sides. The crown will interfere with scraping and, generally, the use of level alleys or pens across the width is recommended. A 10 in curb height is suggested to prevent flush water from entering the freestall. Holding pens and milk parlors may require multiple release valves or more frequent flushing to obtain adequate cleaning.

Water is released into the channels using several different methods. The most common method is use of 12-in-diameter "pop-up" or recessed valves, which open manually or automatically. The valves release the water at the center of the alley. The upper 10 to 20 ft of the channel may not clean as well as the remainder of the channel. Automated valves are pneumatically operated and require a source of compressed air. Discharge rate from a valve is influenced by the hydraulic characteristics of the pipeline feeding the valve. Common design procedures use multiple tanks to feed the valve from two sides and increase the discharge rate. Other release methods include a hinged plate, an open pipe, and a gated pipe. The hinged plate is 12 to 18 in wide and located over a flushing

trough. Water is released into the trough, and the water pressure raises the hinged plate with the flush water being distributed uniformly across the channel. The hinged plate works well with siphon tanks or other high discharge methods and with wider channels such as the holding pen. An open pipe may be a section of pipe extending out of a tank or an entrance ramp. Normally, these are operated manually using a butterfly value. The flush water is directed toward the alley, and distribution of the full width is poor at the upper end. This type of system may require a steep entrance ramp, which hinders animal and vehicle traffic. The gated pipe developed in Missouri has a diameter of 12 to 14 in and nozzles or gates projecting from it to provide directional control of the flush water being released. The pipe is recessed into the floor so that protrusion is limited to 3 to 4 in above the floor. Vehicle and animal traffic can easily cross the gated pipe design.

The flush water is collected at the lower end of the building in a gutter and directed towards a mechanical separator or gravity settling basin. The flushed material is separated to allow the solids to accumulate in a structure or basin and the liquid to drain to a lagoon. Generally, the freestall buildings are flushed with recycled water from the lagoon, and the holding pens and milking parlor are flushed with fresh water. The mechanical separator may be a screen, press roller, or screw press. A screen allows the liquid to pass through it, but the solids remain on the surface and are transferred to a storage area. With a press roller, the flushed material passes through a pair of rollers and the water drains away. The pressing action is designed to produce a drier material. The third mechanical separator is the screw press, which uses more pressure to separate liquids and solids. Gravity type systems use a settling basin to settle out the solids and drain off the liquids. The solids are generally moved to a drying area prior to transporting to a field. Table 4 shows the weight of manure that has to be hauled to a field at different moisture contents and herd size. We assumed that the cows produce 120 lb of manure per day at an initial moisture content of 87.3%. The solids portion of the manure will have a moisture content of 60 to 80% upon exiting a mechanical separator. The moisture content of material exiting a gravity settling structure can be above 90%, with the moisture reduction on the dry slab being dependent on the weather.

Dairies using sand-bedded freestalls need to have a sand trap located above the mechanical separator. The abrasive action of the sand on the pumps and screens in mechanical separators decreases the equipment life and increases the maintenance costs. These increased costs have resulted in many dairies using gravity settling basins with sand-bedded manure. However, the increased operating cost of the mechanical separator has to be compared to the increased cost of transporting higher volumes of material to the fields. Design parameters for the sand trap have not been determined. Some data suggest that flush water has to be slowed from 5 fps to 1.5 fps to allow the sand to settle out and the effluent and manure to be transferred to the mechanical or gravity separators.

## Conclusions

Flushing can be a viable alternative to scraping of dairy manure. Existing facilities can be constructed for the addition of flushing systems at a later date, even if scraping is planned for in the immediate future. This requires placing the buildings at a 2 to 3 percent slope. A 6 to 8 ft difference in elevation between the lower end of the flushed areas and the lagoon freeboard will be necessary for inclusion of separation equipment and transfer collection gutters. Inclusion of flushing systems in existing buildings has to be determined on an individual basis. An adequate water supply for fresh water flushing of the milking parlor and holding pen also must be available.

**Table 1. Volume of Flush Water (gal) Required for Gutters 10 ft Wide Based on Gutter Length and Slope**

| | Gutter Slope (%) | | | | |
|---|---|---|---|---|---|
| Gutter Length (ft) | .5 | 1 | 2 | 3 | 4 |
| 150 ft or less | 3,900 | 2,300 | 1,300 | 950 | 1,100 |
| 200 | 5,250 | 3,000 | 1,750 | 1,250 | 1,250 |
| 300 | 7,850 | 4,500 | 2,600 | 1,900 | 1,900 |
| 400 | 10,500 | 6,000 | 3,500 | 2,500 | 2,500 |
| 500 | 13,100 | 7,500 | 4,350 | 3,100 | 3,100 |
| 600 | 15,700 | 9,000 | 5,200 | 3,750 | 3,750 |
| 800 | 20,900 | 12,000 | 6,900 | 5,000 | 5,000 |
| 1000 | 26,100 | 15,000 | 8,650 | 6,300 | 6,300 |
| Discharge rate (gpm) | 23,500 | 13,500 | 7,800 | 5,600 | 6,500 |

**Table 2. Volume of Flush Water (gal) Required for Gutters 12 ft Wide Based on Gutter Length and Slope**

| | Gutter Slope (%) | | | | |
|---|---|---|---|---|---|
| Gutter Length (ft) | .5 | 1 | 2 | 3 | 4 |
| 150 ft or less | 4,700 | 2,700 | 1,550 | 1,150 | 1,300 |
| 200 | 6,300 | 3,600 | 2,100 | 1,500 | 1,500 |
| 300 | 9,400 | 5,400 | 3,100 | 2,250 | 2,250 |
| 400 | 12,550 | 7,200 | 4,150 | 3,000 | 3,000 |
| 500 | 15,700 | 9,000 | 5,200 | 3,800 | 3,800 |
| 600 | 18,800 | 10,800 | 6,200 | 4,500 | 4,500 |
| 800 | 25,100 | 14,400 | 8,300 | 6,000 | 6,000 |
| 1000 | 31,340 | 18,000 | 10,400 | 7,500 | 7,500 |
| Discharge rate (gpm) | 28,200 | 16,200 | 9,300 | 6,800 | 7,700 |

**Table 3. Volume of Flush Water (gal) Required for Gutters 14 ft Wide Based on Gutter Length and Slope**

| | Gutter Slope (%) | | | | |
|---|---|---|---|---|---|
| Gutter Length (ft) | .5 | 1 | 2 | 3 | 4 |
| 150 ft or less | 5,500 | 3,150 | 1,850 | 1,350 | 1,500 |
| 200 | 7,300 | 4,200 | 2,400 | 1,800 | 1,800 |
| 300 | 11,000 | 6,300 | 3,650 | 2,650 | 2,650 |
| 400 | 14,650 | 8,400 | 4,900 | 3,500 | 3,500 |
| 500 | 18,300 | 10,500 | 6,050 | 4,400 | 4,400 |
| 600 | 21,950 | 12,600 | 7,300 | 5,300 | 5,300 |
| 800 | 29,250 | 16,800 | 9,700 | 7,000 | 7,000 |
| 1000 | 36,600 | 21,000 | 12,100 | 8,750 | 8,750 |
| Discharge rate (gpm) | 32,900 | 18,900 | 10,900 | 7,900 | 9,000 |

**Table 4. Tons of Manure Produced per Day Based on Different Herd Sizes and the Moisture Content of the Solids***

| | Herd Size | | | | |
|---|---|---|---|---|---|
| Moisture Content | 100 | 200 | 400 | 800 | 1600 |
| 30 | 1.1 | 2.2 | 4.4 | 8.7 | 17.4 |
| 40 | 1.3 | 2.5 | 5.1 | 10.2 | 20.3 |
| 50 | 1.5 | 3.0 | 6.1 | 12.2 | 24.4 |
| 60 | 1.9 | 3.8 | 7.6 | 15.2 | 30.5 |
| 70 | 2.5 | 5.1 | 10.2 | 20.3 | 40.6 |
| 80 | 3.8 | 7.6 | 15.2 | 30.5 | 61.0 |
| 87.3 | 6.0 | 12.0 | 24.0 | 48.0 | 96.0 |
| 90 | 7.6 | 15.2 | 30.5 | 61.0 | 121.9 |

*Assume 120 lb of manure per cow per day at 87.3% moisture.

*Dairy Day 1997*

# MANAGING THE NUTRITION PROGRAM FOR COW COMFORT

***J. R. Dunham***


## Summary

Comfortable cows are contented cows. However, cows may be comfortable in their environment but also experience some discomfort because of the nutrition program. A good nutritional management program will improve cow comfort by providing: 1) the proper balance of nutrients for efficient production; 2) buffers for high energy rations to prevent acidosis and sore feet; 3) rations in which grain cannot be consumed too rapidly; 4) rations with proper amounts of nonfiber carbohydrate; 5) highest quality forages during hot weather; 6) additional moisture in total mixed rations during hot weather; 7) a readily available water source; and 8) a bunk management system that encourages cows to eat.


(Key Words: Cow Comfort, Acidosis, Forage Quality, Nonfiber Carbohydrates, Water.)

## Introduction

The goal of a well-managed nutrition program should be to maximize dry matter intake for efficient milk production. All of the items considered in managing the nutrition program affect cow comfort, and comfortable cows are efficient producers. Assuming that a comfortable environment is provided, several nutritional management practices will affect cow comfort.

## Balanced Rations

Everyone knows that rations balanced for energy, protein, minerals, and vitamins are essential for efficient production. Yet, a ration balanced for these nutrients still can result in depressed feed intake caused by acidosis. Acidosis is a digestive upset that causes cow discomfort. Eventually, acidosis will lead to painful foot problems, and cows will be less likely to walk and stand at the feed bunk. Most sore feet originally were caused by acidosis.

High energy rations for early lactation cows should contain buffer to help maintain a desirable pH in the rumen. When rumen pH drops below 6.2, potential exists for acidosis and uncomfortable cows. Anytime the ration contains >.77 Mcal NEL/lb, a buffer should be added at a rate of .75% of the ration dry matter.

High energy rations tend to be rather minimal in fiber content. Even though the ration may contain at least 17% ADF and 27% NDF, acidosis problems still can result from inadequate effective fiber. Effective fiber stimulates cud chewing (rumination). Forages ground or chopped too finely will result in less cud chewing and acidosis.

High levels of nonfiber carbohydrates (NFC) also may cause acidosis. The level of NFC in a ration is an indication of the concentration of starch. Starch is digested rapidly in the rumen and will cause the pH of the rumen to decline rapidly. Anytime the ration contains >42% NFC, other sources of energy such as fat should be substituted for some of the high NFC ingredients.

Feeding a total mixed ration (TMR) prevents cows from selective consumption of ration ingredients and reduces the potential for acidosis by reducing the rate at which cows consume grain. Cows also must eat forage with every bite of grain. Good management will provide a TMR with adequate fiber length.

Cows experiencing sore feet will probably benefit from including zinc methionine in the ration to improve hoof growth.

**Summer Feeding Programs**

Hot weather is associated with depressed feed intake when cows are experiencing heat stress. Cows eat less when under heat stress, because the process of digestion creates additional heat. Feeding programs can be adjusted to make the cows more comfortable and improve feed consumption.

High quality forage will be consumed more readily during the summer because it results in less heat production (heat increment). Even though a ration is formulated with the same fiber content from high or low quality forages, cows will consume more energy and dry matter from the rations containing the high quality forage. Selecting a higher quality forage for summertime and a lower quality forage for winter rations is a good nutritional management program for cow comfort. Relative feed value for alfalfa should be at least 160.

The ration should be concentrated with all nutrients during heat stress, so that less total dry matter is required to meet nutrient requirements. Be sure the fiber content of the ration will meet minimum requirements. Adding fat sources is usually the most feasible way to increase energy density, but some additional grain may be used. Adding a pound of fat will replace 2.25 lb of grain.

When a TMR is fed, cows that are heat stressed will consume more dry matter if water is added to the ration. Increasing the moisture content to about 50% will have a cooling effect on the ration, and cows will consume it faster.

**Water**

Water is the least expensive and one of the most important ingredients in dairy rations. Dry matter intake and water consumption are correlated closely. Water consumption will increase about 50% when the temperature is in the 90's compared to the 70's. Therefore, additional water space will be beneficial on hot days. The water source should be close by and should provide 2 linear ft of space for 20 cows during normal weather. Consider doubling the water space allowance during hot weather.

**Bunk Management**

Bunk management is important for maximum feed intake, because cow comfort will be affected. Allow at least 1.6 linear ft/cow when feeding a TMR. Separating heifers into their own feeding group will reduce competition from older cows.

Feed should be available almost around the clock. All of the feed should be consumed just prior to the next feeding. If not, clean the bunks to prevent spoiled feed from accumulating. Feed cows at least twice daily to keep feed fresh. Feeding early in the morning and late in the evening is recommended during heat stress.

A covered bunk is recommended for cow comfort and to help keep feed fresh. A sprinkling system at the bunk will encourage cows to come to the bunk more often. The bottom of the bunk should be about level with the cows' feet and should have a slick surface.

# THE EFFECTS OF rbST (POSILAC®) ON HEAT-STRESSED, LACTATING, DAIRY COWS

*J. F. Smith, J. E. Shirley, and E. C. Titgemeyer*


## Summary

Two hundred cows located on a commercial dairy in Mesquite, NM were used to evaluate response to rbST (Posilac®) during heat stress in the summer of 1996. Cows were paired by days in milk (average = 153 d at initiation of experiment), parity, and milk yield (average = 92 lb at start of experiment). Prior to initiation of the experiment, all cows received rbST, then rbST treatment was discontinued for one cow from each pair. Milk production was monitored for 4 months. No interactions were detected between lactation number and treatment. Cows maintained on rbST gained .09 of a score (1 to 5 scale) less ($P<.05$) body condition but produced more ($P<.05$) milk in June, July, August, and September. The average milk productions for rbST-maintained vs rbST-discontinued cows were 80.7 vs 73.5 lb/d in June, 80.1 vs 74.6 lb/d in July, 72.6 vs 67.1 lb/d in August, and 65.1 vs 59.2 lb/d in September. Although rbST-discontinued cows had greater declines in production during the first month of the trial, lactation persistency was similar between groups during the final 3 months. Under conditions of heat stress, cows maintained on rbST produced 6.2 lb/d more milk than cows for which treatment with rbST was discontinued.


(Key Words: rbST, Heat Stress, Lactating Cows.)

## Introduction

Many dairy producers who use rbST in their herds have concerns about whether cows under heat stress respond to it. Some producers choose to discontinue the use of rbST during the summer months. A trial was carried out on a 2,000 cow commercial dairy in Mesquite, NM in 1996 to evaluate the effect of discontinuing rbST during heat stress on milk production and body condition.

## Procedures

Two hundred cows were used to evaluate response to rbST (Posilac®) during heat stress in the summer of 1996. Cows were paired by days in milk (average = 153 d at initiation of experiment), parity, and milk yield (average = 92 lb at start of experiment). Prior to initiation of the experiment, all cows received rbST, then rbST treatment was discontinued for one cow from each pair. Individual milk weights were collected monthly for 4 months. Body condition of cows was scored at the beginning and end of the trial. Milk production was analyzed as a repeated measure experiment.

## Results and Discussion

No interactions were detected between parity and treatment. Cows maintained on rbST gained .09 of a score (1 to 5 scale) less ($P<.05$) body condition but produced more ($P<.05$) milk in June, July, August, and September (Table 1). The average milk productions for rbST-maintained vs rbST-discontinued cows are illustrated in Figure 1. Although rbST-discontinued cows had greater declines in production during the first month of the trial, lactation persistency was similar between groups during the final 3 months. Discontinuing supplementation of rbST during periods of heat stress reduced milk production by an average of 6.2 lb/d. Individual dairy operations make the decision whether to

continue supplementing cows with rbST in the summer or to start treating new cows that become eligible for the rbST program in summer months. This decision is complicated, because it involves the economics of using rbST in the summer and will affect the volume of milk cows will produce during the fall. In the decision-making process, producers should evaluate the long-term effects of reducing rbST usage on annual milk production and annual income per cow.

**Table 1. The Effect of Discontinuing rbST (-rbST) on Body Condition Scores of Lactating Cows during Heat Stress**

| Date | rbST | -rbST | SEM* | Probability |
|---|---|---|---|---|
| **5/23** | **2.73** | **2.71** | **.03** | **.65** |
| **9/10** | **3.00** | **3.05** | **.03** | **.31** |
| Change | **.26** | **.35** | **.03** | **.04** |

*For smallest n.

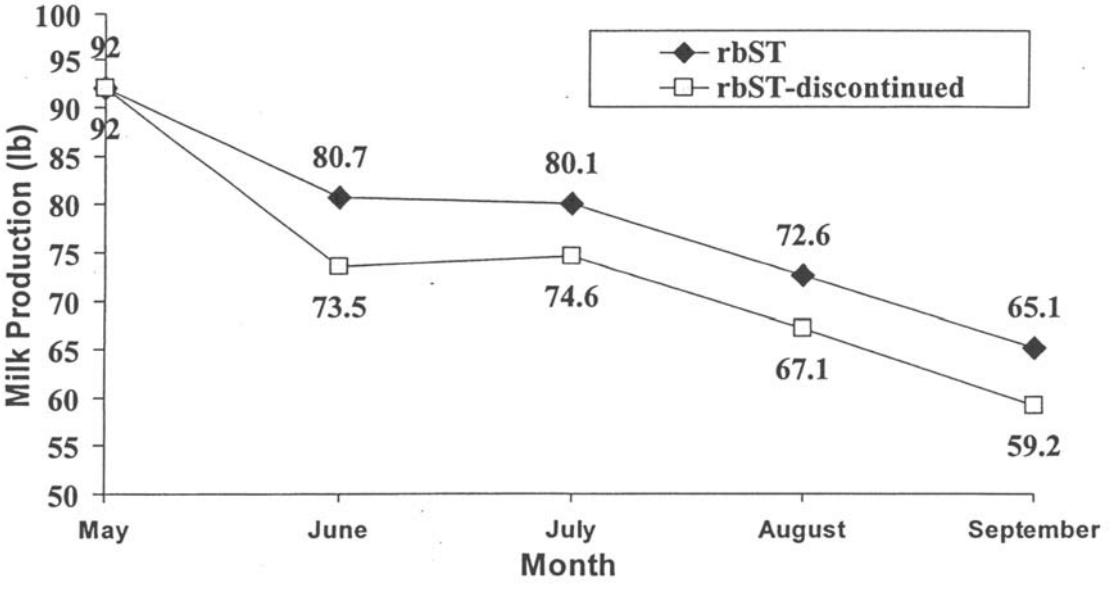


**Figure 1. The Effect of Discontinuing rbST on Milk Production during Heat Stress.**

# EXPELLER SOYBEAN MEAL AS A SOURCE OF RUMEN UNDEGRADABLE PROTEIN FOR LACTATING DAIRY COWS

***J. E. Shirley, D. Piehl, E. Titgemeyer, and M. Scheffel***

## Summary

The loss of meat and bone meal as a source of high quality protein for lactating cows creates an increased need for nonanimal sources. Fifty-six Holstein cows were used to evaluate expeller soybean meal as a source of rumen undegradable intake (by-pass) protein for high producing cows. Expeller soybean meal tended to improve 3.5% fat-corrected milk yield and increased milk fat percentage relative to diets containing either solvent soybean meal or a meat and bone meal:blood meal mixture. In contrast, the protein percentage in milk was depressed significantly when cows were fed expeller soybean meal compared to animal protein. A limiting amino acid (possibly methionine) is implicated.

(Key Words: Lactating Cows, UIP, Expeller Soybean Meal.)

## Introduction

A previous study at Kansas State University determined that expeller soybean meal (SBM) contained 50% undegradable intake protein (UIP) and improved the efficiency of milk production when substituted for solvent SBM in diets fed to dairy cows during mid-lactation. Further, plasma amino acids were elevated in cows fed the expeller SBM relative to those fed solvent SBM. These data suggest that expeller SBM improved the protein status of dairy cows. Although this improvement did not translate into improved milk production, less feed was required to produce a pound of milk. This observation indicates that the diets containing expeller SBM supplied protein in excess of the mammary gland's need to support milk production during mid-lactation.

Dietary UIP is required by genetically superior dairy cows because rumen microbial protein is insufficient to supply the quantity of amino acids required to maximize milk production. Fishmeal, blood meal, and meat and bone meal are recognized as high quality sources of UIP. They are used commonly to increase the UIP percentage in diets for high producing cows during early lactation. In addition, diets containing elevated UIP of high quality generally will support milk production at a lower total dietary crude protein than diets low in UIP.

The purpose of this study was to determine if expeller SBM, containing 50% of the crude protein as UIP, could replace a blend of blood meal and meat and bone meal or solvent SBM as a source of UIP.

## Procedures

Fifty-six Holstein cows were utilized to evaluate mechanically processed expeller SBM as a source of UIP. A blend of blood meal and meat and bone meal was used as a standard for comparison. All cows were fed the high-group herd mix normally used at Kansas State University for the first 28 days postpartum and then assigned to one of the following diets: 1) 18% crude protein, 35% UIP from solvent SBM; 2) 16% crude protein, 35% UIP from solvent SBM; 3) 16% crude protein, 40% UIP from expeller SBM; and 4) 16% crude protein, 40% UIP from a blood meal-meat and bone meal blend. The fat content of the diets was equalized with tallow. Alfalfa hay and corn silage were used for the forage portion of the diets and shelled corn was the primary grain. Diets were evaluated for 84 days.

The diet with 18% CP/35% UIP served as a positive control with which we expected milk production to be optimized. The 16% CP/35% UIP diet was expected to yield less quality milk because it supplied insufficient quantities of amino acids to the cow and served as a negative control. The final two diets with 16% CP and 40% UIP were expected to yield improvements in performance relative to the negative control that were related directly to the ability of the protein sources (expeller SBM and the blood/meat blend) to supply amino acids to the cows.

Cows in dietary treatments were balanced for parity, milk production, and body condition based on pretreatment performance. Treatment comparisons included milk production, dry matter intake, body condition change, body weight gain, and efficiency (lb of milk per lb of feed dry matter consumed). Body weight was measured on 2 consecutive days at the beginning and end of the study and weekly during the study. Body condition was scored weekly. Daily feed intake and milk production were recorded, and milk composition (protein, fat, lactose, and solids-not-fat) was determined weekly. Blood samples were obtained during the pretreatment period and every 3 wk during the study to evaluate energy and protein status.

## Results and Discussion

Compositions of the experimental diets are presented in Table 1. Tallow was used to equalize fat content (energy density) across diets because solvent SBM contained 1.5% fat, expeller SBM contained 5% fat, and meat and bone meal contained 10.4% fat.

Cows fed expeller SBM consumed slightly more dry matter (Table 2) than cows fed the other diets. Milk production was numerically greater from cows fed diets containing 40% UIP than from those fed diets containing 35% UIP. Milk production was similar for cows receiving the 18% and 16% crude protein diets containing 35% UIP. These results are consistent with recommendations of the National Research Council for diets containing approximately 16% crude protein. Other published reports also indicated that high producing dairy cows respond positively to an increase in UIP at lower total dietary protein.

Milk composition among treatments was interesting in that the percent fat and protein tended to move in opposite directions. Expeller SBM increased ($P<.05$) milk fat percentage compared to animal protein and tended ($P=.16$) to increase milk fat percent compared to the 18% protein/35% UIP diet. In contrast, protein percentage was depressed in milk from cows fed expeller SBM compared to cows fed animal protein ($P<.01$), 18% protein/35% UIP ($P<.05$), and 16% protein/35% UIP. The improvement in milk fat percentage resulted in a numerical increase in 3.5% fat-corrected milk from cows receiving the expeller SBM diet compared to the other three diets. Total milk fat (lb/day) was also highest for the expeller SBM diet. Although milk protein percentage was depressed by the expeller SBM diet, total milk protein (lb/day) was similar among the three SBM diets. The animal protein blend led to higher total milk protein (lb/day) than the expeller SBM.

Both expeller SBM and the animal protein blend increased ($P<.05$) total plasma amino acids relative to the negative control (16% solvent SBM) diet (Table 2). Plasma urea nitrogen was highest for the 18% protein diet and, among the 16% protein diets, was lowest for the animal protein blend. The expeller SBM was effective in delivering amino acids to the bloodstream, but the depressed milk protein percentage indicates that amino acids were not translated into milk protein. The expeller SBM diet may have been deficient in at least one essential amino acid. This conclusion is strengthened by the fact that fat percentage was greater in milk from cows fed the expeller SBM diet relative to the other diets. Elevated milk fat percentage has been observed in diets deficient in one or more amino acids.

In conclusion, expeller SBM tended to improve milk and milk fat production but depressed milk protein relative to diets containing a mixture of meat and bone meal and blood meal. Methionine is suggested as being limiting in

heat-treated soy diets. Additional work is underway to verify this hypothesis. If methionine is limiting, the inclusion of corn gluten meal (an excellent source of methionine) in diets containing expeller SBM might improve milk protein percentage.

**Table 1. Experimental Diets: Ingredients as a Percentage of Dairy Matter**

| | Diet[1] | | | |
|---|---|---|---|---|
| | 35% UIP | | 40% UIP | |
| Ingredients | 18% Protein (SSBM) | 16% Protein (SSBM) | 16% Protein (ESBM) | 16% Protein (BM/MBM) |
| Alfalfa | 20 | 20 | 20 | 20 |
| Corn silage | 25 | 25 | 25 | 25 |
| Whole cottonseed | 8 | 8 | 8 | 8 |
| Shelled corn | 26.24 | 30.99 | 29.34 | 33.55 |
| Solvent SBM | 14.10 | 9.50 | -- | 4.80 |
| Expeller SBM | -- | -- | 11.50 | -- |
| Blood meal | -- | -- | -- | 1.20 |
| Meat & bone meal | -- | -- | -- | 2.40 |
| Molasses (wet) | 1.50 | 1.50 | 1.50 | 1.50 |
| Tallow | 1.15 | 1.00 | .65 | .75 |
| Dicalcium phosphate | .833 | .833 | .833 | .208 |
| Limestone | 1.610 | 1.610 | 1.610 | 1.023 |
| Na bicarbonate | .870 | .870 | .870 | .871 |
| MgO | .227 | .227 | .227 | .227 |
| TM salt | .340 | .340 | .340 | .341 |
| Vit ADE | .109 | .109 | .109 | .109 |
| Vit E | .0109 | .0109 | .0109 | .0109 |
| Selenium premix | .0109 | .0109 | .0109 | .0109 |

[1]SSBM = solvent SBM;
ESBM = expeller SBM; and
BM/MBM = blend of blood meal and meat and bone meal.

**Table 2. Response of Dairy Cows to Variable Dietary Protein and Rumen Undegradable Protein**

| | Diet[a] | | | |
|---|---|---|---|---|
| | 35% UIP | | 40% UIP | |
| Item | 18% Protein (SSBM) | 16% Protein (SSBM) | 16% Protein (ESBM) | 16% Protein (BM/MBM) |
| DMI (lb/day) | 57.7 | 57.9 | 59.4 | 58.0 |
| Milk (lb/day) | 91.9 | 90.6 | 94.6 | 94.2 |
| Milk fat (%) | 3.47 | 3.45 | 3.65 | 3.30 |
| Milk protein (%) | 3.10 | 3.09 | 2.98 | 3.16 |
| Milk fat (lb/day) | 3.15 | 3.08 | 3.43 | 3.10 |
| Milk protein (lb/day) | 2.84 | 2.78 | 2.82 | 2.96 |
| Lactose (%) | 4.94 | 5.02 | 5.05 | 5.03 |
| SNF (%) | 8.76 | 8.85 | 8.77 | 8.94 |
| 3.5% FCM[b] (lb/day) | 91.0 | 89.2 | 97.1 | 91.5 |
| ECM[c] (lb/day) | 91.5 | 89.6 | 96.1 | 92.7 |

[a]SSBM = solvent SBM; ESBM = expeller SBM; and BM/MBM = blend of blood meal and meat and bone meal.

[b]Fat-corrected milk.

[c]Energy-corrected milk.

**Table 3. Effect of Variable Dietary and Rumen Undegradable Protein on Plasma Amino Acids and Urea Nitrogen**

| | Diet[1] | | | |
|---|---|---|---|---|
| | 35% UIP | | 40% UIP | |
| Item | 18% Protein (SSBM) | 16% Protein (SSBM) | 16% Protein (ESBM) | 16% Protein (BM/MBM) |
| Amino acid (mg/dl) | 4.11$^{xy}$ | 3.99$^{y}$ | 4.35$^{y}$ | 4.30$^{y}$ |
| Urea nitrogen (mg/dl) | 18.09$^{x}$ | 15.26$^{y}$ | 15.53$^{y}$ | 13.89$^{z}$ |

[1]SSBM = solvent SBM; ESBM = expeller SBM; and BM/MBM = blend of blood meal and meat and bone meal.

[x,y,z]Means within a row without a common superscript letter differ ($P<.05$).

*Dairy Day 1997*

# DEVELOPMENT AND USE OF RECOMBINANT GONADOTROPIN-RELEASING HORMONE VACCINES TO STERILIZE CATTLE: A REVIEW

*J. Greer and T. Rozell*


## Summary

A possible alternative to conventional castration methods is the use of vaccines that can be injected in order to sterilize animals. One promising approach involves the use of a vaccine that causes cattle to produce an immune response against one of their own reproductive hormones, gonadotropin releasing hormone (GnRH). Immunization against GnRH results in a decrease in the amount of GnRH circulating within the animal's blood. Therefore, follicle stimulating hormone (FSH) and luteinizing hormone (LH) are not stimulated to be released, and, subsequently, their levels within the body fall below the levels required for reproductive function. Experimentation has shown that immunization against GnRH can effectively block reproductive function in an age-independent manner but has little effect on carcass and growth parameters. However, about 10% of cattle tested do not respond when immunized against GnRH, regardless of dosing regimen. Further research is needed to improve the efficiency of potential GnRH immunocastration vaccines.


(Key Words: Gonadotropin Releasing Hormone, Follicle Stimulating Hormone, Luteinizing Hormone, Antibody, Immunization.)

## Introduction

Gonadotropin releasing hormone (GnRH) is a neuropeptide synthesized by neurons in the hypothalamus of the brain. GnRH travels to the anterior pituitary via the hypothalamic-hypophyseal portal system, where it triggers subsequent releases of FSH and LH. Released into general circulation, FSH and LH travel to the gonads, where they regulate steroid production, folliculogenesis in the ovary, and spermatogenesis in the testis.

The amino acid sequence of GnRH is common to all mammalian species; pyro-Glu-His-Trp-Ser-Tyr-Gly-Leu-Arg-Pro-Gly-$NH_2$. In theory, immunizing an animal against GnRH would elicit endogenous production of anti-GnRH antibodies within the animal's body. These antibodies then would recognize and neutralize endogenously produced GnRH. Immunization of cattle against GnRH would result in decreased releases of LH and FSH, which, in turn, would inhibit both testicular and ovarian development and function.

## Immunization Effects in Heifers

Active immunization of postpubertal beef heifers, using a vaccine in which GnRH was conjugated to ovalbumin in complete Freund's adjuvant (CFA), was found to induce antibodies against GnRH at a level that could be detected in the serum. These same heifers also were found to have retarded follicular growth, with most ovaries showing no developing follicles. Pregnancy tests were negative for all immunized heifers (n=7) at the time of slaughter following an 8-week breeding period. In contrast, control animals had a pregnancy rate of 71%. Further studies found that active immunization of heifers against similar GnRH constructs resulted in decreases in: the number of receptors for GnRH within the pituitary, concentrations of LH within the pituitary, serum progesterone levels, ovarian weight, uterine weight, follicular development, and cyclic activity. Multiple immunization of cyclic beef heifers with GnRH conjugated to human serum albumin (HSA) and injected in diethylaminoethyl (DEAE)-dextran adjuvant not only invoked and maintained anti-GnRH titers, but also induced a state of anestrus in 29 of 34 heifers for 82.8 ± 6.9 days. This effect was not dependent on the dose of vaccine.

Research has shown that immunization of prepubertal heifers against GnRH can delay the onset of puberty. In 12-month-old heifers receiving two injections of GnRH-HSA in CFA 6 weeks apart, puberty was delayed by an average of 175 days. A single immunization delayed the onset of puberty by an average of 112 days. Presumably, these delays were due to decreases in the secretion of LH and FSH, which ordinarily stimulate development of the ovaries at the time of puberty.

A potential concern about the use of sterilization vaccines is that the immunization ultimately may cause a decline in the release of certain growth-promoting (anabolic) steroids. Multiple studies have demonstrated that GnRH-immunization treatments reduced average daily gain (ADG) in feedlot heifers but did not affect overall carcass quality. This decreased growth performance likely was due to reduced estradiol secretions from acyclic ovaries in GnRH-immunized individuals. This theory is supported by early research showing ovariectomized heifers as generally having reduced ADG rates. We should note, however, that reductions in ADG in both pre- and postpubertal heifers immunized against GnRH can be overcome by the use of estradiol implants. Additionally, these losses in ADG are less than those seen when heifers become pregnant in the feedlot.

A commercial anti-GnRH vaccine, Vaxtrate®, is currently in use in Australia. Vaxtrate is a GnRH-ovalbumin conjugate administered in a DEAE-dextran and mineral oil adjuvant. This vaccine is used primarily to prevent pregnancy in feedlot cows and heifers at times when pregnancy is of biological and economical disadvantage (pregnant animals generally gaining less and bringing a lower price per pound at slaughter). Cattle usually are dosed twice at an interval of 4 or 16 weeks. Currently, producers using Vaxtrate® are seeing an 80% decline in the incidence of pregnancy among vaccinated animals. Unfortunately, Vaxtrate® is not available in the United States because of restrictions placed on vaccine production by the Food and Drug Administration (FDA).

## Immunization of Steers and Bulls

Both single- and double-dose administration of a vaccine consisting of GnRH conjugated to keyhole limpet hemocyanin (KLH) induced long-lasting, high levels of anti-GnRH antibodies. In these animals, LH concentrations in the serum were decreased, and immunized bulls also had retarded testicular growth and decreased epididymal weight. Immunization also elicited atrophy of secondary sex organs, including the prostate and seminal vesicles.

Immunization against GnRH did not affect the average daily gain in bulls and steers to the extent seen in heifers, and carcass characteristics of the immunized animals were comparable to those of control individuals. Immunization effects also were not dependent on age.

## Considerations for Vaccine Production

In both bulls and heifers, one problematic aspect of vaccination against GnRH is the failure of some treated animals to respond to treatment—overall about 10% of all injected animals failed to respond to GnRH immunization whether given one or two injections. Additionally, research has shown that, in order to maintain castration status, repeated dosage is necessary in at least part of the cattle population. Success rate is dependent on several factors, including vaccine construct and adjuvant. Current research at Kansas State University is examining the efficiency of various construct/adjuvant combinations as well as investigating the potential use of an "immunological cocktail", which would elicit an immunological response against GnRH, LH, and FSH. The aim of these studies is to create an efficient, permanent vaccine for use in both male and female cattle, as well as satisfying the previously mentioned FDA requirements for vaccines used in food animals. One of these requirements is that the vaccine must have an easily identifiable structure that is perfectly consistent from batch to batch. Current conjugation techniques (such as those used to

produce Vaxtrate®) do not meet these criteria. Therefore, we are utilizing recombinant DNA techniques to produce vaccines against GnRH that will evoke an immune response, as well as have an identifiable structure (by reading the DNA sequence of the construct) that is consistent from batch to batch.

## Conclusions

Development of a reliable, permanent, immunological, castration vaccine has obvious economical and ethical advantages. Castration via injection would reduce veterinary costs and man-hours spent castrating and treating domestic livestock species--this is particularly true for the females who are not so easily or economically sterilized. It also provides obvious reduced risks of infection and complications, not to mention less stress on the animal. Although immunological castration agents are not yet ready for commercial use, such vaccines likely will be viable future alternatives to conventional castration methods.

# SYNCHRONIZATION OF ESTRUS AND OVULATION IN DAIRY HEIFERS USING NORGESTOMET, GnRH, AND $PGF_{2\alpha}$ [1]

***J. S. Stevenson, K. E. Thompson, J. F. Smith, and D. E. Hawkins*** [2]

## Summary

Two experiments were performed using the same treatments. All heifers received two injections of $PGF_{2\alpha}$ 14 days apart. Controls then were inseminated after detected estrus. Heifers assigned to the two treatments also received 6 mg of norgestomet for 8 days beginning 7 days before the second of two $PGF_{2\alpha}$ injections. The heifers in the last treatment also received GnRH 48 hr after the second $PGF_{2\alpha}$ injection to induce ovulation in any heifer not observed in estrus before a fixed-time insemination at 72 hr after $PGF_{2\alpha}$. In Experiment 1, any control heifer or heifer in the two treatments not detected in estrus by 72 hr after $PGF_{2\alpha}$ received a fixed-time insemination at 72 hr. Heifers receiving GnRH tended to have fewer standing events and a shorter duration of estrus. Fixed-time inseminations reduced conception compared to those after detected estrus. In Experiment 2, when inseminations were performed only after detected estrus, all measures of fertility were unaffected by treatments. These results indicated that addition of norgestomet and(or) GnRH did not improve measures of estrus synchronization or fertility of dairy heifers.

(Key Words: Estrus Synchronization, Standing Estrus, Hormones, Heifers.)

## Introduction

The objectives of estrus-synchronization programs are to control precisely the onset of estrus and facilitate the use of A.I.-breeding and fixed-time inseminations. Because a progestin implant removed within 48 hr after the corpus luteum is regressed by $PGF_{2\alpha}$ generally improves the onset and synchrony of estrus, fixed-time inseminations at 48 to 54 hr after progestin withdrawal have produced acceptable conception rates in beef heifers. Injection of GnRH causes the release of luteinizing hormone (LH) from the pituitary gland and induces ovulation of a preovulatory-size follicle. Follicles ovulate between 24 and 32 hr after GnRH injection. Therefore, the objective of two experiments reported herein was to determine whether treating heifers with $PGF_{2\alpha}$ plus the addition of norgestomet and(or) GnRH would improve estrus-detection rates and subsequent measures of fertility.

## Procedures

### Experiment 1

Pubertal Holstein replacement heifers at the Kansas State University Dairy Teaching and Research Center were used in three replications during January (n = 11), February (n = 9), and August (n = 11) of 1996. Each heifer was fitted with a HeatWatch® rump-mounted device (DDx, Inc., Denver, CO) to measure estrual activity during an estrus-synchronization program consisting of two treatments and a control (Figure 1). Control heifers ($2\times PGF_{2\alpha}$) received two injections of $PGF_{2\alpha}$ (Lutalyse®, Pharmacia & Upjohn, Kalamazoo, MI) 14 days apart before inseminations were made after detected estrus. Any heifer not inseminated by 72 hr after $PGF_{2\alpha}$

[1]We thank two corresponding dairy producers for their assistance with this study:George Segura (Big Sky Dairy) and Joe Segura (Valley View Dairy).

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received one fixed-time insemination at 72 hr. A second group of heifers also received two injections of $PGF_{2\alpha}$ 14 days apart plus one ear implant containing 6 mg of norgestomet (Syncro-Mate-B implant; Rhone-Merieux, Inc., Athens GA) 7 days before the second $PGF_{2\alpha}$ injection ($2\times PGF_{2\alpha}$+N); the implant was removed 24 hr after $PGF_{2\alpha}$. Inseminations were made after detected estrus. Any heifer not inseminated by 72 hr after $PGF_{2\alpha}$ received one fixed-time insemination at 72 hr. A third group of heifers also received two injections of $PGF_{2\alpha}$ 14 days apart plus one ear implant containing 6 mg of norgestomet (Syncro-Mate-B implant; Rhone-Merieux, Inc., Athens GA) 7 days before the second $PGF_{2\alpha}$ injection; the implant was removed 24 hr after $PGF_{2\alpha}$. In addition, 100 µg of GnRH (Cystorelin®, Rhone-Merieux, Inc., Athens, GA) was administered 48 after the second injection of $PGF_{2\alpha}$ ($2\times PGF_{2\alpha}$+N+G). Inseminations were made after detected estrus or remaining heifers received one fixed-time insemination 18 hr after GnRH or 72 hr after $PGF_{2\alpha}$. Inseminations were made by one technician using semen from one sire. Pregnancy was diagnosed by palpation of the uterus and its contents between 38 and 52 days after insemination.

From 10 control heifers and from five heifers in each of the two treatments, daily blood samples were collected beginning at the first injection of $PGF_{2\alpha}$ and continuing until 48 hr after the second $PGF_{2\alpha}$ injection. Concentrations of estradiol-17 and progesterone were measured in blood serum with specific validated radioimmunoassays. Hormonal concentrations were plotted for each heifer and normalized to the peak in estradiol-17 that occurred near the onset of estrus after the second $PGF_{2\alpha}$ injection.

The estrus-detection rate was calculated as the proportion of heifers detected in estrus by visual observation (twice daily) or by the HeatWatch device during the first 96 hr after the second $PGF_{2\alpha}$ injection. Conception rate was the proportion of heifers detected and inseminated that became pregnant. Pregnancy rate was the proportion of heifers that became pregnant of the total treated. Calving rate was the proportion of heifers that calved of the total treated. The interval from $PGF_{2\alpha}$ to the onset of estrus, duration and number of standing events per heifer in estrus, and duration of standing heat were calculated using information collected by the HeatWatch system.

**Experiment 2**

An experiment using the same treatments was conducted on two dairy farms (Big Sky and Valley View dairy farms) located in southern New Mexico during February, March, and May of 1996. Dairy heifer replacements (n = 287) were treated as in Figure 1. A total of six sires was used between the two dairy farms. All inseminations were performed after detected estrus, and in one herd, a second insemination was given if the heifer was in estrus at the next heat check period. Clean-up bulls were used after three unsuccessful inseminations. Pregnancy was diagnosed by calving date, assuming that a normal distribution of gestation for Holstein heifers was 280 ± 14 days (266 to 294 days). Any heifer not calving during this period after the treatment insemination became pregnant to a repeat insemination or to the clean-up bull. Estrus-detection, conception, pregnancy, and calving rates were calculated as in Experiment 1.

## Results and Discussion

**Experiment 1**

Results of the first experiment are summarized in Table 1. Interval to the onset of estrus was in the 55- to 67-hr range and not different among treatments; however, the estrus-detection rate tended to be greatest in the heifers given norgestomet without the subsequent GnRH treatment. The number of standing events during estrus was reduced ($P<.05$) when GnRH was given at 48 hr after $PGF_{2\alpha}$. Similarly, the duration of estrus tended to be less for that same treatment, whereas duration of individual standing events was not different. Conception, pregnancy, and calving rates were similar, but each measure tended to be less in the last treatment with GnRH. Heifers that received the fixed-time insemination had lower ($P<.01$) conception rates than those inseminated after a detected estrus (21.3 vs 82.5%).

Profiles of estradiol- 17 and progesterone in blood serum were not different between the controls and those additionally treated with norgestomet (Figure 2).

These results indicate that administration of GnRH following the removal of the norgestomet implant may have suppressed estrual behaviors such as standing activity and duration of estrus, despite similar peak concentrations of estradiol-17 near the onset of estrus.

**Experiment 2**

Results of the second experiment are summarized in Table 2. In this experiment, inseminations were performed only after detected estrus. Es&us-detection, conception, pregnancy, and calving rates were unaffected by treatments. Herd and sire effects were detected for conception and pregnancy rates. Interval to inseminations after PGF, was 1 day later in one herd than in the other herd. In 22.8% of the heifers, double inseminations were made at estrus, and a tendency (P=.13) for improved conception was detected (73.8 vs 60.9%). These results indicate that the addition of norgestomet and(or) GnRH did not improve either estrus synchrony or any measure of fertility.

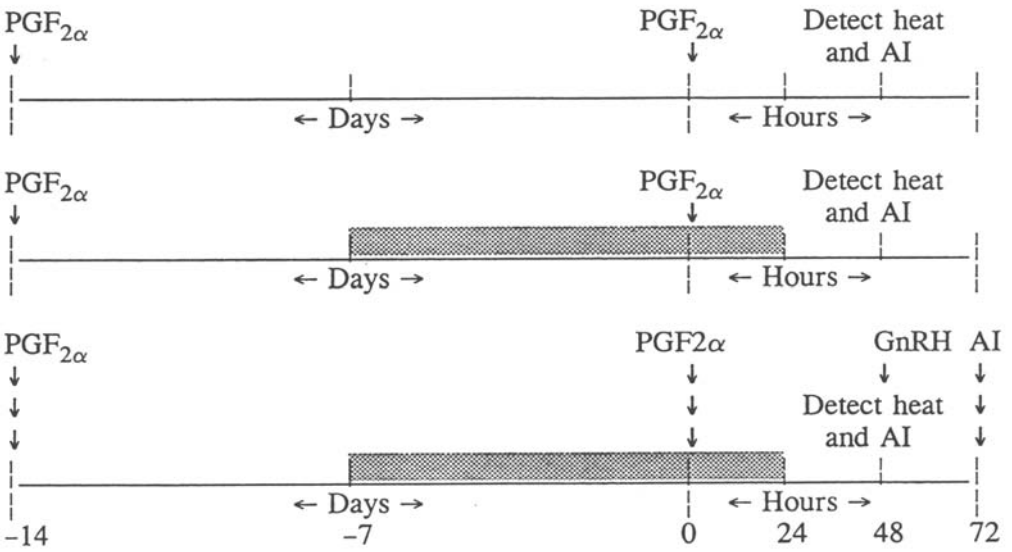


**Figure 1. Treatment Protocol for Experiments 1 and 2.** Inseminations were performed after detected estrus or at 72 hr after the second PGF,, injection in the absence of estrus in Experiment 1. Inseminations were made only after detected estrus in Experiment 2. = 6-mg norgestomet implant.

**Table 1. Reproductive Performance of Kansas Holstein Heifers**

| | Treatment | | |
|---|---|---|---|
| Item | 2×$PGF_{2\alpha}$ | 2×$PGF_{2\alpha}$+N | 2×$PGF_{2\alpha}$+N+G |
| No. of heifers | 14 | 9 | 8 |
| Estrus-detection rate[1], % | 53.4 | 87.9 | 47.7 |
| $PGF_{2\alpha}$ to onset of estrus, hr | 55.0 | 66.6 | 57.4 |
| No. of standing events[2] | 23.1 | 21.5 | 5.6 |
| Duration of stands[1], sec | 3.1 | 2.9 | 2.5 |
| Duration of estrus, hr | 15.2 | 11.8 | 6.1 |
| Conception rate[3], % | 60.6 | 45.5 | 49.7 |
| Pregnancy rate[3], % | 50.0 | 49.4 | 34.8 |
| Calving rate, % | 92.2 | 98.6 | 88.9 |

[1]Replicate effect ($P<.05$).
[2]Treatment effect ($P<.05$).
[3]Estrus vs fixed-time AI ($P<.01$; 82.5 vs 21.3%).

**Table 2. Reproductive Performance of Two Herds of New Mexico Holstein Heifers**

| | Treatment | | |
|---|---|---|---|
| Item | 2×$PGF_{2\alpha}$ | 2×$PGF_{2\alpha}$+N | 2×$PGF_{2\alpha}$+N+G |
| No. of heifers | 101 | 92 | 94 |
| Estrus-detection rate, % | 94.4 | 93.1 | 88.9 |
| $PGF_{2\alpha}$ to AI[1], d | 3.5 | 3.9 | 3.4 |
| Conception rate[2], % | 69.5 | 62.4 | 70.0 |
| Pregnancy rate[3], % | 69.5 | 61.6 | 70.0 |
| Calving rate, % | 84.5 | 86.3 | 92.8 |

[1]Herd effect ($P<.05$; 3.1 ± .2 vs. 4.2 ± .4)
[2]Herd ($P<.05$) and sire ($P = .07$) effects.
[3]Herd ($P = .05$) and sire ($P<.10$) effects.

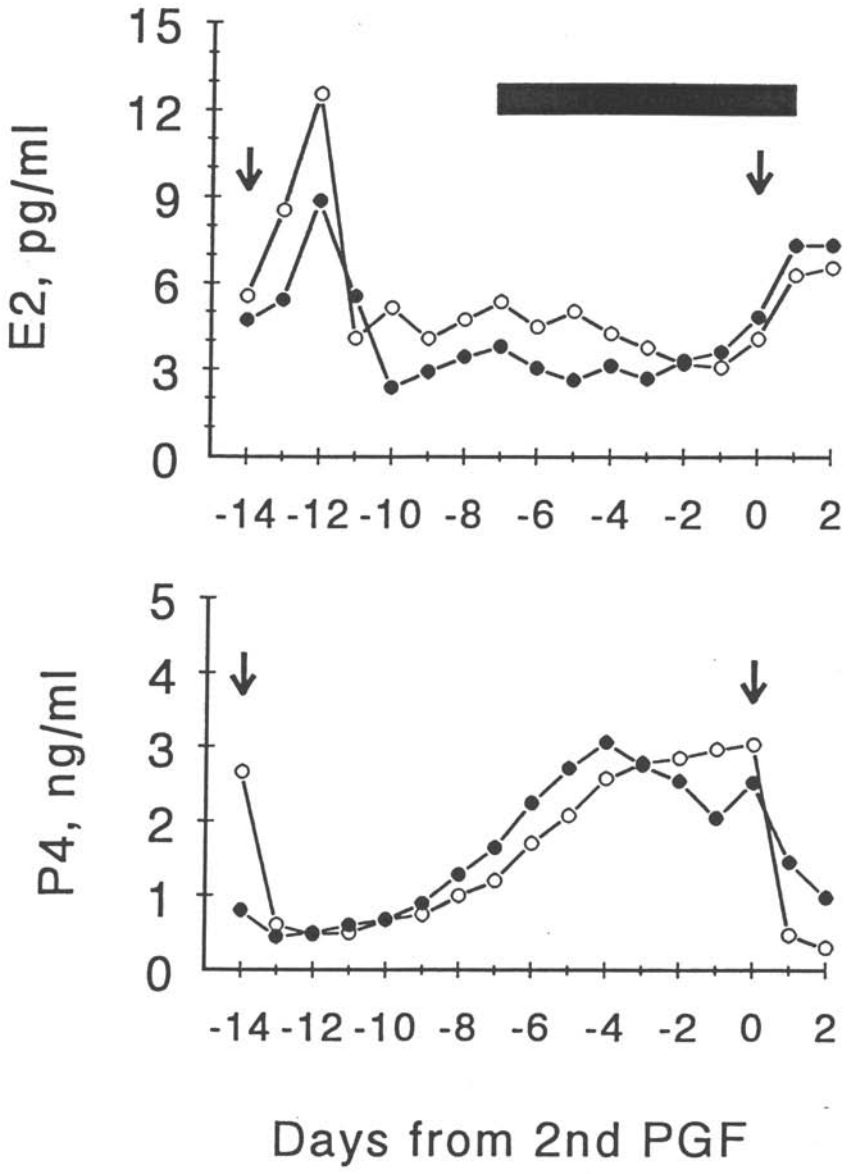


**Figure 2. Daily Concentrations of Estradiol-17 and Progesterone in Blood Serum of Dairy Heifers during 14 Days before and 2 Days after the Second of Two PGF,, Injections (Arrows) in Controls (0; n = 10) or Norgestomet-Treated Heifers (0; n = 10).** Concentrations were normalized to the peak of estradiol-17 that occurred near the onset of estrus after the second PGF,, injection.
-= norgestomet treatment during 8 days.

# VARIOUS ESTRUS-SYNCHRONIZATION PROGRAMS FOR HEIFERS

***J. S. Stevenson***


## Summary

Various programs of estrus synchronization have been tested during the last 6 years to determine the least costly and most efficacious for dairy heifer replacements. Four systems were tested: 1) a modified Ovsynch treatment (GnRH 7 days before $PGF_{2\alpha}$ followed by GnRH either at 24, 30, 33, 40, or 48 hr, with one fixed-time insemination 16 to 20 hr later); 2) a similar protocol that used GnRH 7 days before $PGF_{2\alpha}$ followed by insemination at estrus (GnRH+$PGF_{2\alpha}$); 3) inseminations after one or two injections of $PGF_{2\alpha}$ given 14 days apart ($PGF_{2\alpha}$; heifers not detected in estrus after the second of two $PGF_{2\alpha}$ injections were given one fixed-time insemination at 72 hr); and 4) two injections of $PGF_{2\alpha}$ given 14 days apart followed by GnRH at 33 hr, with one fixed-time insemination 16 to 18 hr later (2×$PGF_{2\alpha}$+GnRH). The $PGF_{2\alpha}$ treatment in which heifers were inseminated after detected estrus following one or two injections of $PGF_{2\alpha}$ was the least costly for heifers and produced the best measures of fertility.


(Key Words: GnRH, $PGF_{2\alpha}$, Estrus Synchronization, Heifers.)

## Introduction

During the last 20 years, various estrus-synchronization programs have been tested to control precisely the onset of estrus and facilitate the use of A.I.-breeding and fixed-time inseminations. In the past 5 years, the hypothalamic decapeptide, gonadotropin-releasing hormone (GnRH) has been used in various schemes to control follicular development in conjunction with $PGF_{2\alpha}$ to control the life span of the corpus luteum. Three GnRH products (Cystorelin®, Factrel®, and Fertagyl®) and two $PGF_{2\alpha}$ products (Lutalyse® and Estrumate®) are available currently. Together, both hormones offer several options in controlling the estrous cycle in dairy heifers before A.I.-breeding. The objective of this brief report is to summarize the results for heat-detection, conception, and pregnancy rates achieved in four different programmed-breeding systems.

## Procedures

Holstein heifers housed at the Kansas State University Dairy Teaching and Research Center were used in various experiments between 1991 and 1997. Heifers ranged in age from 11 to 16.5 months (avg = 13.4 months) and in weight from 745 to 1133 lb (avg = 880 lb) near the onset of each experiment. Descriptions of the various treatments are found in Figure 1. The dose of $PGF_{2\alpha}$ used was 25 mg (5 ml of Lutalyse®, Pharmacia & Upjohn, Kalamazoo, MI). The dose of GnRH was 100 µg (Cystorelin®, Rhone-Merieux, Athens, GA). Pregnancy was diagnosed by palpation of the uterus and its contents between 38 and 52 days after insemination.

## Results and Discussion

Results of these experiments are summarized in Table 1. Rates of heat detection were less ($P<.05$) in the modified Ovsynch and 2×$PGF_{2\alpha}$+GnRH treatments than in the GnRH+$PGF_{2\alpha}$ and $PGF_{2\alpha}$ treatments because the GnRH injection given at 24, 30, 33, 40, or 48 hr after $PGF_{2\alpha}$ in the modified Ovsynch treatment produced expression of estrus in only 14.2, 0, 20, 61.5, or 52.2% of the heifers treated at those times, respectively. Reports indicate that some heifers show heat between the injections of GnRH and $PGF_{2\alpha}$; however, similar heat-detection rates occur whether intervals between GnRH and $PGF_{2\alpha}$ are 6 or 7 days.

The LH released from the pituitary gland in response to GnRH will prevent further secretion of estradiol-17 by the maturing preovulatory ovarian follicle and thus prevent some sexual behaviors associated with estrus. Detection of heifers in estrus following the GnRH+$PGF_{2\alpha}$ hormonal sequence is very good and compares to that when heifers receive two injections of $PGF_{2\alpha}$ (78.7%). In contrast, the combined heat-detection rate of heifers detected after one injection of $PGF_{2\alpha}$ (inseminated at that time) and those detected after the second of two $PGF_{2\alpha}$ injections improves to 93.3%.

Conception rates (based on those inseminated after detection of estrus or at one fixed time) were reduced ($P<.05$) in the modified Ovsynch and the 2×$PGF_{2\alpha}$+GnRH treatments compared to the other two treatments (Table 1). This reduction in conception rate in the latter treatments generally occurs because all inseminations are given at one fixed time compared to most inseminations made after detected estrus in the other two treatments (GnRH+$PGF_{2\alpha}$ and $PGF_{2\alpha}$). The best conception rate occurred in the GnRH+$PGF_{2\alpha}$ treatment, where all inseminations were made after detected estrus; however, even in the $PGF_{2\alpha}$ treatment, inseminations made at 72 hr after the second $PGF_{2\alpha}$ injection in the absence of detected estrus actually produced an acceptable conception rate (15 of 20 or 75%) compared to that after detected estrus (15 of 27 or 55.6%). Pregnancy rates followed very closely results for conception rates. Regardless of the method used, the total pregnancy rates after repeat inseminations exceeded 90% in each treatment.

When comparing the per-heifer cost of hormones used in the various treatments, the modified Ovsynch system is most expensive ($15). The remaining treatments, in order of hormonal cost, are: 2×$PGF_{2\alpha}$+GnRH = $12; GnRH+$PGF_{2\alpha}$ = $9; and $PGF_{2\alpha}$ = $3-6 (depending on whether the heifer is detected in heat after the first or second $PGF_{2\alpha}$ injection). Based on the economics of treatments, the $PGF_{2\alpha}$ treatment is the least costly method that seems to maximize measures of fertility with the least handling of each heifer before insemination.

**Table 1. Reproductive Performance of Holstein Heifers after Various Programs**

| | Treatments[1] | | | |
|---|---|---|---|---|
| Item[2] | Modified Ovsynch | GnRH+ $PGF_{2\alpha}$ | $PGF_{2\alpha}$ | 2×$PGF_{2\alpha}$ +GnRH |
| No. of heifers | 88 | 60 | 77 | 25 |
| Estrus-detection rate, % | 31.7[a] | 87.4[b] | 83.7[b] | 20.9[a] |
| Conception rate, % | 39.3[a] | 71.6[b] | 61.3[b] | 55.8[ab] |
| Pregnancy rate, % | 40.5[a] | 61.7[b] | 59.0[b] | 55.5[ab] |
| Total pregnancy, % | 98.0 | 95.8 | 91.4 | 95.3 |
| No. of handlings (per heifer) | 3 | 2 | 1-2 | 3 |
| Cost of hormones[3], $ | 15 | 9 | 3-6 | 12 |

[1]See Figure 1 for descriptions of treatments.

[2]Estrus-detection rate = proportion of heifers detected in heat during the 72-hr detection period of the total assigned to treatment. Conception rate = proportion of heifers detected in heat and inseminated that became pregnant. Pregnancy rate = proportion of heifers that became pregnant during the 72-hr detection period of the total assigned to treatment. Total pregnancy = proportion of treated heifers eventually conceiving in the herd after repeat inseminations.

[3]Veterinary costs for $PGF_{2\alpha}$ = $3 and GnRH = $6.

[a,b]Percentages with different superscript letters differ ($P<.05$).

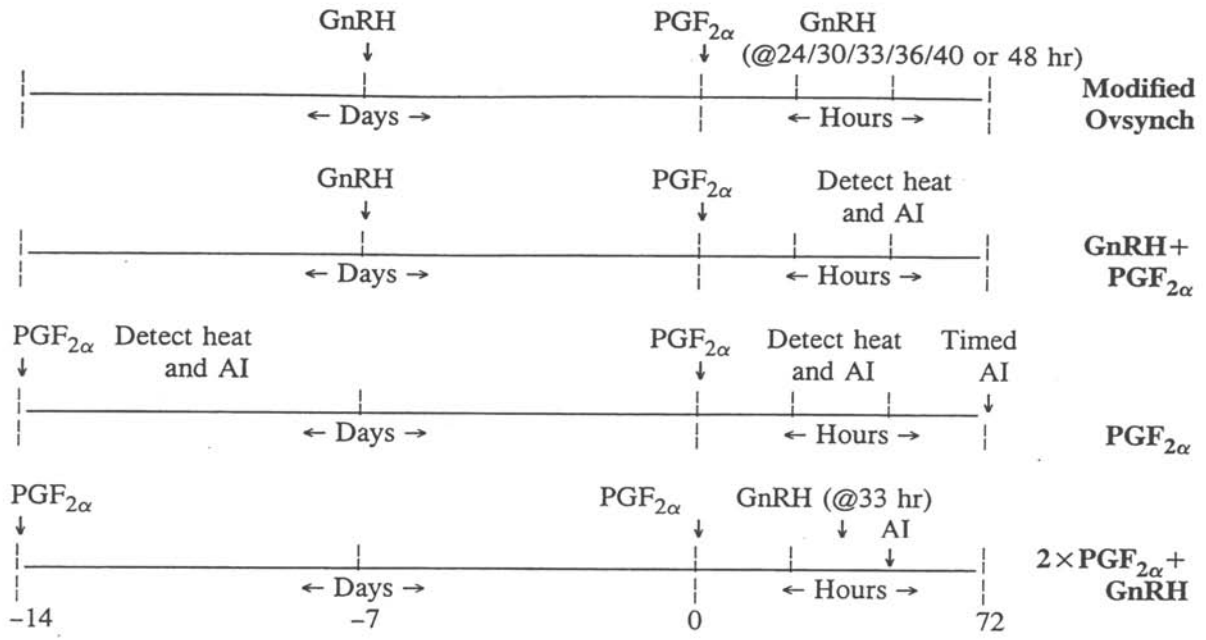


**Figure 1. Experimental Protocols.** Modified Ovsynch = GnRH 7 days before $PGF_2$; second GnRH given at either 24, 30, 33, 40, or 48 hr after $PGF_2$; insemination between 16 and 20 hr after GnRH. GnRH + $PGF_2$ = GnRH 7 days before $PGF_2$; insemination after detected estrus. $PGF_2$ = two injections of $PGF_2$ given 14 days apart; insemination followed detected estrus after either the first or second injection of $PGF_2$. Any heifer not detected in estrus by 72 hr received a fixed-time insemination at 72 hr. 2x$PGF_2$ + GnRH = two injections of $PGF_2$ given 14 days apart; GnRH given 33 hr after the second $PGF_2$ injection; insemination 16 to 18 hr after GnRH.

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# CONCEPTION AND PREGNANCY RATES IN DAIRY COWS AFTER VARIOUS PROGRAMMED BREEDING SYSTEMS

*J. S. Stevenson, K. E. Thompson, and Y. Kobayashi*


## Summary

Two experiments were conducted to measure conception and pregnancy rates in lactating dairy cows after various treatments followed by artificial insemination (AI) after detected estrus or at one fixed time. In Experiment 1, Holstein cows in one herd were assigned randomly to four treatments every 3 wk (27, 3-wk cluster groups): 1) Ovsynch33, 2) GnRH+$PGF_{2\alpha}$, 3) 2×$PGF_{2\alpha}$, and 4) 2×$PGF_{2\alpha}$+GnRH. In Experiment 2, Holstein cows in one herd were assigned randomly to two treatments every 3 wk (14, 3-wk cluster groups): 1) Ovsynch48 and 2) GnRH+$PGF_{2\alpha}$. In both experiments, frozen-thawed semen from multiple sires was used, one technician performed >95% of all inseminations, and pregnancy was diagnosed by palpation per rectum between 38 and 52 d after first insemination. Although actual conception rates resulting from inseminations after detected estrus were consistently greater, pregnancy rates of cows were superior after fixed-time inseminations because of poor rates of detected estrus in treatments that relied solely on observation of sexual behavior.


(**Key Words:** OvSynch, Synchronized Estrus, Conception and Pregnancy Rates.)

## Introduction

Attempts to develop estrus-synchronization systems for lactating dairy cows and accommodate a fixed-time insemination have met with limited success since prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) was demonstrated to be effective in controlling the estrous cycle for programmed breeding. Conception rates following $PGF_{2\alpha}$ usually were best when inseminations were performed after observed signs of heat. Our early attempts to use fixed-time inseminations at first services in lactating dairy cows demonstrated that conception rates were less than desirable.

Follicular development must be controlled and synchronized with the regression of the corpus luteum after $PGF_{2\alpha}$ in order to reduce variation in the intervals to estrus. Precise control of follicular development with the regression of the corpus luteum should allow improved conception rates associated with one fixed-time insemination. Such a synchronized ovulation protocol (OvSynch) has been tested. A first injection of GnRH is administered 7 days before $PGF_{2\alpha}$, and a second injection of GnRH is given 36 to 48 hr after $PGF_{2\alpha}$ to ovulate the dominant follicle via GnRH-induced release of luteinizing hormone (LH). The objective of these experiments was to compare conception and pregnancy rates in lactating dairy cows after various programmed breeding systems used to synchronize estrus before first postpartum inseminations. Specifically, we wished to determine the: 1) effect of incorporating GnRH in a two $PGF_{2\alpha}$ injection scheme (administration of GnRH after the second $PGF_{2\alpha}$ injection), 2) actual pregnancy rates among systems that require or do not require detection of estrus, and 3) timing of second GnRH injection at either 33 or 48 h after $PGF_{2\alpha}$ in the OvSynch system.

## Procedures

**Experiment 1.** Four treatments were used (Figure 1). Treatments A and B were similar. One injection of GnRH (100 µg of Cystorelin®) was given 7 days before one injection of $PGF_{2\alpha}$ (25 mg of Lutalyse®). In treatment A, cows received a second injection of GnRH 33 hr after $PGF_{2\alpha}$ and then one fixed-time insemination 18 hr later, whereas cows in treatment B were

inseminated according to the AM-PM rule at the detected estrus after $PGF_{2\alpha}$.

Treatments C and D were similar. All cows received two injections of $PGF_{2\alpha}$ 14 days apart. In treatment C, cows received one injection of GnRH 33 hr after $PGF_{2\alpha}$ and one fixed-time insemination 18 hr later. In the last treatment, cows were inseminated at the detected estrus after $PGF_{2\alpha}$ according to the AM-PM rule or in the absence of detected estrus, one fixed-time insemination was given at 80 hr (cows) after the second $PGF_{2\alpha}$ injection.

Treatments were applied randomly to lactating cows (minimum of 62 days in milk) before first services. Cow were grouped in 3-wk breeding clusters beginning in June, 1994, and the experiment continued until December, 1995. Conception rates were determined by palpation of the uterus and its contents between 38 and 52 days after insemination.

**Experiment 2.** Treatments A and B of Experiment 1 were repeated in lactating cows, except that the second injection of GnRH was administered 48 hr after $PGF_{2\alpha}$ (Figure 2). Lactating cows (minimum of 58 days in milk) before first services were grouped in 3-wk breeding clusters beginning in December, 1995 and ending in March, 1997. Conception rates were determined by palpation of the uterus and its contents between 38 and 52 days after insemination.

## Results and Discussion

**Experiment 1.** Estrus-detection, conception, and pregnancy rates achieved in each of four treatments are summarized in Table 1. The proportion of cows detected in heat during 96 hr after $PGF_{2\alpha}$ was less ($P<.01$) in treatments A and C in which GnRH was administered after $PGF_{2\alpha}$ to induce ovulation of the follicle. This GnRH injection caused estrogen secretion by the preovulatory follicle to cease and, therefore, prevented further mounting and standing activity in most cows. Conception rates (proportion of cows detected in estrus and inseminated that became pregnant) were not significantly different among treatments; however, conception rates tended to be greater in those treatments (B and D) in which AI was administered after detected estrus. In treatment B, cows not detected in estrus after the initial synchronization were inseminated at their next nonsynchronized estrus, and 8 of 22 (36.4%) conceived. In treatment D, 24 of 46 (52.2%) cows inseminated at estrus conceived, and 8 of 55 (14.6%) conceived in the absence of detected estrus when inseminated at 80 hr after the second of two $PGF_{2\alpha}$ injections.

Pregnancy rates (proportion of cows assigned to treatment that became pregnant) were more uniform among treatments. The similar pregnancy rates, despite lower actual conception after fixed-time inseminations, resulted from rather poor heat-detection rates in treatment B. Treatment D, similar to the Targeted Breeding® system, produced the greatest pregnancy rates.

**Experiment 2.** Heat-detection, conception, and pregnancy rates in Experiment 2 are illustrated in Table 2. Heat-detection rates were less ($P<.01$) in the Ovsynch48 treatment compared to treatment B in which a second GnRH injection was not administered after $PGF_{2\alpha}$. These rates were quite similar to those observed in Experiment 1. Conception rates tended to be lower in the Ovsynch treatment, but the reverse was true for pregnancy rates. This reversal was due to the rather poor heat response in treatment B.

As long as poor heat-detection rates occur after various programmed-breeding treatments, pregnancy rates (the number of pregnancies achieved per unit of time) always will be superior with a treatment that utilizes a fixed-time insemination. Treatment D in Experiment 1 and Ovsynch48 in Experiment 2 produced the most pregnancies per unit of time.

## Conclusions

Actual conception rates tended to be less after fixed-timed inseminations, whereas conception rates tended to be greatest when inseminations occurred after detected estrus. Pregnancy rates tended to be less when programmed breeding systems depended partly or wholly on detection of behavioral estrus, whereas they were greatest after fixed-time inseminations. Conception (pregnancy) rates are probably maximized after OvSynch when the second GnRH injection is given closer to 48 h after $PGF_2$. Fixed-time inseminations with a two-injection $PGF_2$ system may achieve acceptable conception (pregnancy) rates if GnRH is given closer to 48 h after the second $PGF_2$ injection (before fixed-time insemination), but this needs to be tested.

## Recommendations

The recommended use of the OvSynch protocol is to administer GnRH on Monday, followed by $PGF_2$ on the following Monday at milking time (5 PM), administer the second GnRH injection at 5 PM on Wednesday (48 hr later), and inseminate cows the next morning (Thursday) between 8 and 10 AM (Figure 2). If you do not want to use the timed insemination, give GnRH (Monday), follow it with $PGF_2$ in 7 days (Monday), and watch for heat. For inseminations with this system, follow the AM-PM rule when heat is detected. Do not use the Ovsynch protocol in replacement heifers, because results are inferior to what can be achieved with a $PGF_2$ protocol.

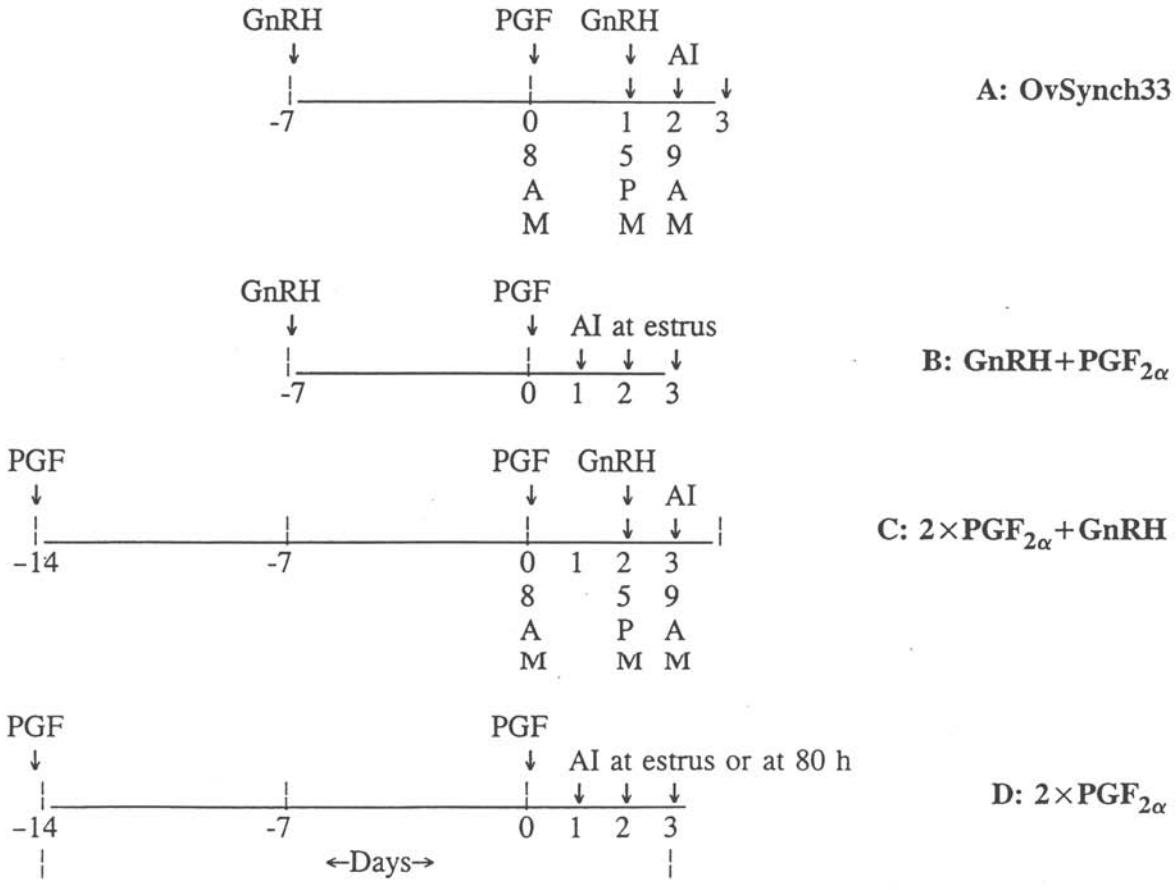


**Figure 1. Treatment Protocols for Experiment 1.**

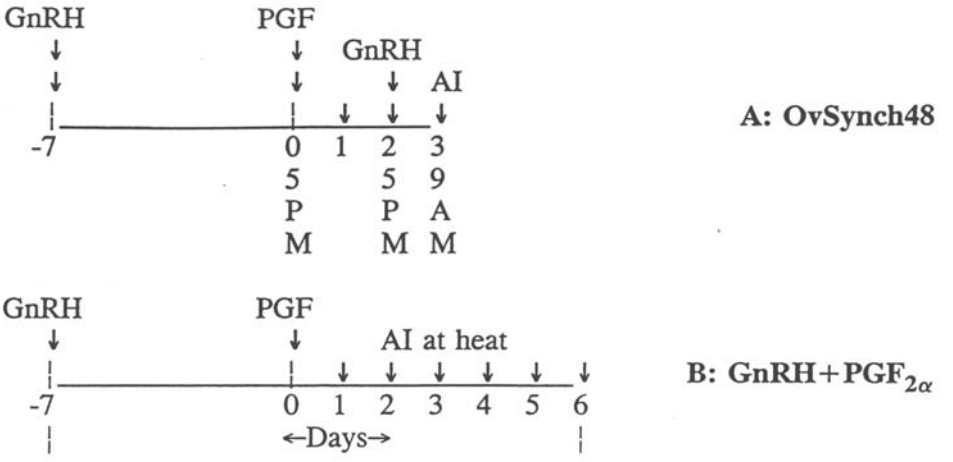


**Figure 2. Treatment Protocols for Experiment 2.**

**Table 1. Results of Experiment 1 with Four Programmed Breeding Systems**

| Item | OvSynch33 | GnRH +PGF[1] | 2xPGF +GnRH | 2xPGF[2] |
|---|---|---|---|---|
| No. of cows | 68 | 74 | 64 | 101 |
| Detection rate, % | 7.4[a] | 71.6[b] | 6.2[a] | 53.5[c] |
| Conception rate, % | 22.1 | 35.8 | 25.0 | 31.7 |
| Pregnancy rate, % | 22.1 | 25.7 | 25.0 | 31.7 |

[1]Conception of 22 cows inseminated at next estrus = 8/22 (36.4%).
[2]Cows inseminated at estrus = 24/46 (52.2%). Cows inseminated at 80 h = 8/55 (14.6%)
[a,b,c]( P < . O 1 ) .

**Table 2. Results of Experiment 2 with Two Programmed Breeding Systems**

| Item | OvSynch48 | GnRH+PGF |
|---|---|---|
| No. of cows | 112 | 107 |
| Detection rate, % | 16.1[a] | 62.6[b] |
| Conception rate, % | 34.8 | 43.9 |
| Pregnancy rate, % | 34.8 | 27.4 |

[a,b]($P<.01$).

# ATP BIOLUMINESCENCE CAN EVALUATE CLEANING AND SANITIZING EFFECTIVENESS IN THE MILKING PARLOR[1]

*M. J. Meyer and K. A. Schmidt*

## Summary

Four areas of the milking parlor were evaluated for effective cleaning and sanitation using total aerobic counts (standard plate count) and ATP bioluminescence (ATPB) techniques. Whereas the plate counts only monitor bacterial numbers, the ATPB results (reported as relative light units, RLU) also indicate residual soil or food residue on the surface. Results showed little correlation between the RLU values and the aerobic plate count data; however, the ATP bioluminescence technique detected the presence of soil residue on the contact surface. The ATP bioluminescence system is a fast (<2 min) and simple method that evaluates the effectiveness of cleaning and sanitation procedures employed.

(Key Words: Milking Parlor, HACCP Plan, Sanitation, ATP Bioluminescence.)

## Introduction

Cleanliness of the milking parlor is very important in maintaining high quality raw milk. Although most people think of bacterial as being the main determinants of raw milk quality, other factors, such as cleanliness and protein quantity, can have an effect. Generally, as raw milk quality decreases, shelf life and usefulness also decrease. Because milk from a healthy animal contains little, if any, microbial contamination, any surface that milk contacts is a potential contaminating source.

The typical way to monitor the cleanliness of an area is to swab its surface and then use plating and incubation techniques to enumerate the number of microorganisms on the surface (TPC or total plate count). These values are reported as colony forming units per area or volume ($CFU/cm^2$ or ml). The downfall of this technique is that it only measures the number of aerobic microorganisms and not the presence of soil or food residue. This microbial technique is time consuming (24 to 48 hr before results are available), requires a fair amount of knowledge, and is expensive (both reusable and nonreusable equipment and resources are necessary).

The ATP bioluminescence (ATPB) system is relatively new. Currently, this technology is used to monitor sanitation effectiveness in food processing plants. The ATPB monitors both microbial loads and food residue but fails to distinguish between the two. An effective sanitation program relies on the cleanser to remove soil and food residue and the sanitizer to kill microorganisms. The ATPB is relatively simple (training time of 30 min) and produces results within 2 min of swabbing a contact surface. The downfall of the ATPB is that nebulous values are generated and referred to as relative light units (RLU). Each user must develop his or her own RLU limits to designate "clean", "warning" (values are elevated and may indicate some contamination), and "dirty" zones (values are too high and the surface needs to be recleaned).

A milking parlor environment is very different from a food plant environment. But with the increased concern for food safety, consumers and legislators have suggested that HACCP (Hazard Analysis Critical Control Point) plans be considered and possibly established to start at the "farm" and end at the "plate". In this situa-

[1]The authors thank Biotrace LTD (Brigend, UK) for use of the instrument and Kansas State University College of Agriculture Honors Program for partial funding of this project.

tion, it will be important that sanitation procedures can be verified in a milking parlor, so that milk contact surfaces do not contaminate the milk. As with all verification procedures, obtaining results quickly and accurately is important. Thus, the question was asked, can the ATPB be used to ascertain cleaning and sanitation effectiveness in the milking parlor?

## Procedures

Four milk contact areas were identified in the milking parlor located at the Kansas State University Dairy Teaching and Research Center. Location A was the inside of a rubber inflation liner on the milker claw. Location B was the inner surface of the milk filter canister. Location C was the inside of the milk line going into the milk tank, and location D was the interior of the refrigerated bulk tank. For locations A, B and C, swabs were taken after running the 7-minute sanitizing cycle using common Clorox® bleach (500 mL) as the sanitizing agent. Swabbing of these locations was done 10 min after the sanitizing cycle was completed. Location D was cleaned independently, by an automatic bulk tank cleaning system. On two sample dates, swabbing was done 15 min after the tank had been sanitized on the hot acid wash cycle. On the other sample date, the bulk tank contained raw milk at 2.8°C or 37°F.

Over a 17-day period, the four locations (either 2.5 $cm^2$ or 5 $cm^2$) were swabbed with a sterile cotton swab moistened with sterile peptone broth. These broth samples were refrigerated, transported to the KSU Dairy Plant Laboratory, and analyzed for total number of aerobic microorganisms (TPC) following standard procedures using Petrifilm®. The TPC values were standardized and reported as the number of colony forming bacteria/ml of sample (CFU/ml).

No accept or reject limits exist for TPC values for food contact surfaces; however, the general rule is the lower, the better. For a dairy processing plant, TPC values of greater than 100 CFU/ml are potentially problematic and require recleaning.

To evaluate the ATPB system, the Biotrace Uni-Lite™ Xcel Luminometer (Biotrace, Ligend, England) was used. For these samples, Biotrace Uni-Lite™ swabs were used on adjacent areas of the microbial swabs. These Uni-Lite™ swabs were placed back into their carriers, activated by an enzyme solution. The end products of this reaction produce light, which is sensed by the hand held Uni-Lite™ Xcel Luminometer, generating the RLU value within 45 seconds. The higher the value, the more contamination (microbes, food residue, or soil) is present on the food contact surface.

Biotrace designates the following ranges: acceptable--less than 250 RLU (clean surface) and unacceptable--greater than 300 RLU (dirty surfaces). Values between 250 to 300 RLU would be in the questionable zone. These limits adequately evaluate sanitation in a food processing operation.

## Results and Discussion

Preliminary work showed that we could obtain accurate and precise results. For swabs from clean, sanitized surfaces, RLU values were low, and microbial counts generally were not detected. In addition, the results agreed with previous research. No correlation was detected between the microbial counts and RLU values. The only apparent trend was that swabs from dirty surfaces had higher RLU values and CFU/ml (in certain circumstances) counts than did swabs from clean surfaces.

Thus, three different scenarios from the milking parlor are shown and discussed. Because the experimental conditions vary, results are shown independently and not combined. Results of our three trials are shown in Tables 1, 2, and 3.

Results varied considerably. Table 1 depicts the results of cleaning and sanitizing before swabbing. All RLU values are less than 250, indicating a thorough cleaning and sanitizing. The TPC results produced no growth, indicating an effective sanitation program. Considering both sets of data, we concluded that the milking equipment and raw milk bulk tank had been cleaned and sanitized adequately and should not add contaminants to the raw milk.

Note that the two different tests produced different information.

In Table 2, a different situation is shown. On this date, the bulk tank contained raw milk. When the tank was sampled, swabbing occurred close to milk line and tried to incorporate some milk residue (from splashing) in the swabbed samples.

Results in Table 2 indicate that locations A and B would pass a cleaning/sanitation inspection from either a TPC count or an RLU value. Location C would not pass an inspection from either test, but location D would pass by the TPC count, but not by the RLU value. This will be explained further.

When these two situations are considered independently, the RLU value at location C indicates that this surface is not clean and should be recleaned before using. The TPC data indicate that the counts are less than 250 CFU/ml. Microbial counts between 100 to 250 CFU/ml would warrant that this piece of equipment be recleaned before milk runs through this pipe. The TPC results required 48 hours to obtain. Obviously, milk would have run through this pipe before the results were available. Quick turn-around of cleaning might have prevented contamination of raw milk.

Location D produced mixed results. TPC results show a sanitized milk tank, whereas the ATPB results indicate dirty surfaces in the bulk tank. This scenario illustrates that milk residue is measured by the ATPB system, but not the TPC. The TPC results show only microbial contamination, but the RLU value indicates microbes (apparently minor) and residual dirt or milk left on the surface. Based on both sets of results, we could conclude that sanitation may have occurred, but the cleaning step was omitted.

Table 3 shows the third scenario. Locations A and D would pass inspection, whereas locations B and C would fail inspection by either technique. The logical conclusion would be that surfaces A and D are cleaned and sanitized; locations B and C would need to be recleaned and resanitized before use.

The results for locations B and C (Table 3) show a strange relationship. In location B, the TPC count is higher and RLU value lower than the comparable results from location C. This is contrary to what would be expected. This situation shows the lack of a linear relationship between TPC counts and RLU values. The TPC results are real numbers. Higher TPC counts mean more microbes present per unit surface area. A surface with 1000 CFU/ml is more contaminated than a surface with 100 CFU/ml. The same cannot be said about RLU values. A surface with 900 RLU is not necessarily more dirty than a surface with a 350 RLU reading.

This technology still can be used to distinguish between clean and dirty surfaces. At this time, RLU values are only "relative" and cannot be used to quantitate the amount of contamination or microbes on a surface. In this case, if the RLU values were over 300, the TPC counts either indicated that poor sanitation occurred, or we knew that it was a "dirty" surface. Thus, we conclude that the ATPB can be used to evaluate the sanitation effectiveness in the milking parlor.

## Conclusions

This work indicates that the ATPB system is useful to monitor appropriate cleaning and sanitation programs. If either step is overlooked, RLU values are elevated. With the Biotrace unit, guidelines of <250 as acceptable and >300 as unacceptable seem to hold true for the milking parlor as well as a food processing plant. The advantages of the ATPB method are its speed (less than 5 min) and ease (minimal instructional time). As HACCP farm to plate plans are realized, this technology may provide a viable, easy method to verify adequate cleaning and sanitation procedures.

**Table 1. Standard Plate Counts (TPC) and ATP Bioluminescence (ATPB) Results (November 15, 1996)**

| Location | ATPB | TPC |
|---|---|---|
| | RLU | CFU/ml |
| A - milk claw | 81 | NG[1] |
| B - milk filter canister | 173 | NG |
| C - milk line | 41 | NG |
| D - raw milk tank | 20 | NG |

[1]NG = no growth.

**Table 2. Standard Plate Counts (TPC) and ATP Bioluminescence (ATPB) Results (November 22, 1996)**

| Location | ATPB | TPC |
|---|---|---|
| | RLU | CFU/ml |
| A - milk claw | 45 | NG[1] |
| B - milk filter canister | 136 | 41 |
| C - milk line | 319 | NSG[2] |
| D - raw milk tank | 2279 | NG |

[1]NG = no growth.
[2]NSG = no significant growth, in this situation, <250 CFU/ml estimated, as defined by *Standard Methods for the Examination of Dairy Products*.

**Table 3. Standard Plate Counts (TPC) and ATP Bioluminescence (ATPB) Results (December 1, 1996)**

| Location | ATPB | TPC |
|---|---|---|
| | RLU | CFU/ml |
| A - milk claw | 39 | NG[1] |
| B - milk filter canister | 325 | 2760 |
| C - milk line | 935 | 270 |
| D - raw milk tank | 18 | NG |

[1]NG = no growth.

# EXPLAINING DIFFERENCES IN EFFICIENCY AMONG DAIRY OPERATIONS

***P. T. Berends [1], M. R. Langemeier [2], and A. M. Featherstone [2]***

## Summary

To remain competitive, dairy operations need to continue to improve production efficiency and manage costs. Kansas Farm Management Association data from 1991 to 1995 were used to measure technical, economic, and overall efficiencies for 50 dairy operations in Kansas. On average, the farms showed .87 technical, .71 economic, and .67 overall efficiency. The latter was related negatively to labor, capital, feed, and fuel and utility expenses per cow. Veterinarian expenses were related positively to overall efficiency. Overall efficiency was the most sensitive to changes in feed expenses per cow, emphasizing the importance of controlling this cost. Results also indicated that a larger proportion of overall inefficiency was due to cost control problems than to an inefficient herd size.

(Key Words: Efficiency, Profitability.)

## Introduction

The U.S. dairy industry has gone through some dramatic changes during the last 5 to 10 yr. Two forces are driving structural change. The first force relates to technologies or innovations. Innovations or increases in the understanding of the biological process have made specialization more feasible. In addition to increasing production efficiency, specialization often has led to a reduction in production costs. The second force relates to economies of size. Advances in technology and management practices have increased the maximum size of operation that can be managed effectively.

To remain competitive, dairy operations need to continue to improve production efficiency and manage costs. One of the key ways to accomplish these objectives is the adoption of new technologies. However, before new technologies can be adopted, information pertaining to the current level of efficiency and cost of production is needed. High-cost producers need to examine their strategic position before expanding or implementing new technologies. The objective of this study was to examine the efficiency of a sample of dairy operations in Kansas.

## Procedures

Kansas Farm Management Association data for 50 dairy operations from 1991 to 1995 were used in this study. The efficiency analysis required data on output, inputs, and costs of production. Output was measured as total pounds of milk produced. Input cost categories included labor, capital, dairy, feed, fuel and utilities, veterinarian expenses, and miscellaneous. Labor costs included hired labor and a charge for unpaid operator labor. Capital costs included interest, repairs, depreciation, and machinery hired. The opportunity charges associated with owning facilities were included in capital costs. Dairy expenses included marketing and transportation costs. Input costs were converted to real 1995 dollars.

[1]University of Wisconsin, Platteville.

[2]Department of Agricultural Economics.

Table 1 presents the mean and standard deviations of gross income, costs, profit, and selected farm characteristics. On average, the farms lost about $139 per cow during the 5-yr period. Feed costs comprised about 50% of the total cost per cow. Labor and capital costs accounted for 15 and 17% of total cost per cow, respectively. Average herd size was about 96 cows, and the average amount of milk produced per cow was about 18,100 lb.

Technical efficiency measures the extent to which a farm uses the best available technologies. Economic efficiency measures the extent to which a farm minimizes cost for a given level of output. A farm can be economically inefficient because of technical inefficiency or allocative inefficiency (resulting from a failure to use inputs in a cost efficient manner). Overall efficiency represents the minimum cost of producing a given level of output using constant returns to scale technology. Overall inefficiency can be due to economic inefficiency or not producing at the most efficient size. A series of mathematical programs was used to measure technical, economic, and overall efficiencies. Regression coefficients were used along with the means of the variables to compute elasticities. The elasticity measures provided information on the sensitivity of efficiency to each input cost. Efficiency estimates were used as the dependent variables in the regressions. Independent variables included the seven cost categories.

**Table 1. Summary Statistics for a Sample of Kansas Dairy Farms, 1991-1995**

| Variables | Unit | Mean | Standard Deviation |
|---|---|---|---|
| Gross revenue per cow | $ | 2,677 | 506 |
| Labor expense per cow | $ | 409 | 167 |
| Capital expense per cow | $ | 476 | 155 |
| Dairy expense per cow | $ | 274 | 111 |
| Feed expense per cow | $ | 1,412 | 296 |
| Fuel and utility expense per cow | $ | 105 | 44 |
| Veterinary expense per cow | $ | 72 | 48 |
| Miscellaneous expense per cow | $ | 69 | 73 |
| Profit per cow | $ | -139 | 436 |
| Age of operator | yr | 50 | 12 |
| Milk produced per cow | lb | 18,062 | 3,090 |
| Herd size | no. | 96 | 68 |
| Total acres operated | no. | 979 | 696 |
| Acres in forage production | % | 28 | 17 |
| Farms classified as cash crop farms | % | 25 | 44 |
| Farms classified as mixed farms | % | 4 | 20 |
| Hired labor expense/total labor expense | % | 48 | 38 |
| Debt to asset ratio | % | 31 | 26 |
| Farms operated by sole proprietor | % | 56 | 50 |

Source: Kansas Farm Management Associations.

## Results and Discussion

Table 2 reports distributional information for technical, economic, and overall efficiencies. Technical efficiency ranged from .57 to 1. About 28% of the farms were technically efficient or were producing milk at a high level. Average technical efficiency for the sample of dairy operations was .87, indicating that the output of these farms could potentially be increased by 11%, if each farm were operating on the production frontier.

Economic efficiency ranged from .45 to 1 and averaged .71. If all of the farms had been operating on the average cost frontier, the same level of output could have been produced with 29% less cost. Only 6.8% of the farms had an economic efficiency index that was greater than .90. In contrast, 45.6% of the farms had a technical efficiency index that was greater than .90. Thus, producing on the cost frontier was more difficult for these farms than producing on the production frontier.

Overall efficiency ranged from .44 to 1 and averaged .67. If all of the farms had been operating at minimum cost, the same level of output could have been produced with 33% less cost. Significant cost savings occurred up to a size of about 500,000 lb. The average cost curve was relatively flat once this output level was reached. In addition, more variation in production costs existed in operations of similar size than for efficient operations of different sizes. Thus, dairy operators should focus on controlling costs rather than changing operation size.

Elasticities are reported in Table 3. An asterisk indicates that the variable was significant ($P<.05$) in the corresponding regression. Labor, capital, feed, and fuel and utilities were significant and related negatively to overall efficiency, indicating the importance of controlling these cost items. Reducing labor and feed costs by 10% would increase overall efficiency by 1.1 and 2.3%, respectively. Conversely, increases in veterinary expenses lead to an increase in overall efficiency. Possible improvements in herd health and milk production per cow resulting from increases in veterinary expenses may explain this result.

**Table 2. Efficiency Measures for a Sample of Kansas Dairy Farms (1991-1995)**

| Variable | Technical Efficiency | Economic Efficiency | Overall Efficiency |
|---|---|---|---|
| Summary statistics (index) | | | |
| Mean | .87 | .71 | .67 |
| Standard deviation | .12 | .12 | .10 |
| Minimum | .57 | .45 | .44 |
| Maximum | 1.00 | 1.00 | 1.00 |
| Distribution of farms (%) | | | |
| | | ))))))))) % ))))))))) | |
| 0 to .50 | 0.0 | 2.0 | 4.0 |
| .50 to .60 | 2.4 | 16.0 | 21.6 |
| .60 to .70 | 6.4 | 32.0 | 39.2 |
| .70 to .80 | 21.6 | 27.2 | 25.2 |
| .80 to .90 | 24.0 | 16.0 | 7.2 |
| .90 to 1.00 | 17.6 | 4.4 | 2.4 |
| 1.00 | 28.0 | 2.4 | .4 |

**Table 3. Input Use Elasticities for a Sample of Kansas Dairy Farms (1991-1995)**

| Variable | Technical Efficiency | Economic Efficiency | Overall Efficiency |
|---|---|---|---|
| Labor expense per cow | -.0586* | -.0918* | -.1134* |
| Capital expense per cow | -.0069 | -.0838* | -.0880* |
| Dairy expense per cow | -.0965* | -.0682* | -.0191 |
| Feed expense per cow | -.0493 | -.2023* | -.2267* |
| Fuel and utility expense per cow | -.0157 | -.0016 | -.0403* |
| Veterinary expense per cow | -.0068 | .0541* | .0650* |
| Miscellaneous expense per cow | -.0087 | -.0109 | -.0144 |

*Indicates that the regression coefficient used to compute the elasticity was significant ($P < .05$).

## INDEX OF KEY WORDS

Indexer's note: The numbers indicate the first pages of each article that uses the listed key word.

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## BIOLOGICAL VARIABILITY AND CHANCES OF ERROR

Variability among individual animals in an experiment leads to problems in interpreting the results. Although the cattle on treatment X may have produced more milk than those on treatment Y, variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than from chance.

In some of the articles herein, you will see the notation "$P < .05$". That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be "significantly different", the probability is less than 5% that the difference is from chance or the probability exceeds 95% that the difference resulted from the treatment applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one ($+1$ or $-1$). If there is no relationship, the correlation is zero.

In other papers, you may see an average given as $2.5 \pm .1$. The 2.5 is the average; .1 is the "standard error". The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Using many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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