THE STRATEGY AND ECONOMICS OF MASTITIS CONTROL

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STRATEGY

Two main approaches may be made to mastitis control. The first involves conducting individual herd investigations in an attempt to discover the causes of existing infections. This approach includes extensive use of laboratory services and specific advice for each herd. Such an approach is not practical on a large scale because half of the cows in most herds are infected and require special investigation. Also, even with the best technical equipment it is often impossible to discover the precise reasons for a high level of infection.

The second, and more practical approach, is the use of a control system that is effective in most herds and does not require investigations by specialists. The primary objective of such a system must be to reduce subclinical staphylococcal and streptococcal infections to low levels. To be acceptable, the control system must cost less than the disease itself, be relatively simple to carry out, work under most management conditions, and substantially reduce clinical mastitis soon after being adopted.

For practical reasons the effectiveness of a mastitis control scheme is assessed in terms of the reduction in level of infection (i.e., the proportion of cows or quarters infected) rather than the reduction in the rate of new infection. The level of infection in a herd depends both on the rate of new infection and on the duration of each infection. At first glance the influence of duration of infection may not be obvious but it can be illustrated with a simple example. If one new infection occurs once each week and infections last for 1 week, then one new infection will be present at any given time. However, if the infections last 4 weeks, then four infections will be present at any given time.

The duration of infection has another important effect in that it determine the rate of change in the level of infection. If the rate of new infection in a herd is reduced, the level of infection will fall to a new equilibrium, and the time taken to reach the new level will be the average duration of the infections. The factors influencing level of infection are simplified as follows:
A \quad B \quad C

Average level of infection = \quad \text{Total cows infected in period} \times \frac{\text{Average duration \times \frac{1}{100}}}{\text{infected cows remain infected}}

(% cows infected) = (as \% of total cows)

If either B or C are reduced by 50%, the level A will fall by 50% and if both B and C are reduced by half, the level will fall by 75%. This means that effective control could be obtained with modest reductions in both rate and duration of infection. It must be recognized that if such a control is started and the level falls by 75% the new level will not be maintained unless the steps taken to reduce both rate and duration are continued. If either B or C increase then there will be a directly proportionate increase in the level of infection.

It is important to note that the relationships discussed do not give any indication of the time required for the reduction in level of infection to occur, but a control relying on reducing new infection alone would act very slowly because of the high average duration of infection. The reason for this can be seen by expanding the B term in the equation given above.

\begin{align*}
B & \quad D \quad E \\
\text{Total cows infected in period} & = \quad \text{Cows infected at start of period} + \quad \text{Cows uninfected at start becoming infected in period} \\
(as \% \text{ of total cows}) & = (\% \text{ of total cows})
\end{align*}

Data from an extensive field experiment revealed that B = 80% of cows, D = 56% of cows, and E = 24% of cows. Therefore, even if a preventive system was completely effective and no new infection occurred the total cows infected would decline by less than one third during a 12-month period. Long-term programs for mastitis control should be based on the prevention of new infection, but it must also be recognized that with any control system designed to reduce staphylococcal and streptococcal infections the rate of decline of infection in the first year will depend much more on how much the duration of infection is reduced than on the reduction in the rate of infection.

Prevention of Infection

The Streak Canal. The streak canal is the portal of entry into the udder for mastitis organisms. Thus, in any effort to effectively prevent infections emphasis must be given to protecting the integrity of the canal.

The streak canal is normally a very effective barrier to the
penetration of bacteria. It is approximately 10 mm long and is closed by the sphincter muscle except during milking. A healthy canal provides an environment that is continually repressive to microbial growth due to the presence of cationic proteins. On the other hand, a damaged streak canal is easily colonized by bacteria which invade the udder at a rate at least tenfold higher than in the case of normal canals.

Bacteria may overcome the barrier of the teat canal by multiplication, mechanical movement, or propulsion during milking. It seems likely that in most cases a combination of factors is involved.

Transfer of Pathogens. Bacteria from quarters with clinical or subclinical mastitis, together with those from infected teat lesions, are spread from cow to cow on the milker's hands, udder cloths, and milking machine clusters. Most milking routines include foremilking, udder washing, and some degree of machine stripping. Therefore, even with the best hygiene methods, some transfer of pathogens will occur at milking time. Methods that aid in reducing this transfer include incorporating a sanitizer in the water used for preparing the udder and the use of a single-service paper towel.

Teat Dipping. The dipping of teats immediately after milking with a safe and effective product is the most important single practice that a dairy farmer can employ for preventing new infections. Teat dipping does not exert a rapid effect on the level of infection in a herd because it does not affect existing infections, but its importance in a long-term program of mastitis prevention cannot be over-emphasized.

An efficient teat dipping program is normally very effective in preventing intramammary infection even when the teats are experimentally exposed to bacteria immediately before milking. This implies that pathogens contaminating teats before and during milking are important mainly because they leave teats contaminated after milking and permit colonization of the teat duct. Thus, the main effect of a post-milking teat dip is to destroy pathogens left on teats after milking and to prevent streak canal colonization. This observation suggests that a significant percentage of new infections occur during the interval between milkings. Effective dips also reduce the number of infected teat lesions and increase the healing rate of existing ones.

During the past 5 years extensive studies have been conducted in Louisiana on teat dips. The findings have revealed that the rate of infection is reduced by more than 50% when teats are dipped with effective products. Recent work on 59 teat dip products revealed that approximately 20% of the products were not effective against common mastitis pathogens. Fortunately, most of the ineffective products are being modified or removed from the market by the manufacturer.

Role of Milking Machines. It is well known that milking machines influence the incidence of udder disease by acting as a vector for transferring pathogens between and within cows, and as a traumatic
factor causing external lesions on teats if they are not properly maintained and used.

Recently, extensive research studies were undertaken on milking machines in England. Though this work is still in its early stages, a few important conclusions can be gleaned from the data. These are summarized as follows.

1. The combination of cyclic and irregular fluctuations in vacuum, coupled with fast movement of the inflation wall, caused an increase in the infection rate.

2. Most machine-induced infections occurred near the end of milking, thus confirming the long-standing recommendation that cows should not be overmilked.

3. A close correlation existed between new infections and the occurrence of impacts on the end of the teat. Impacts may be defined as tiny droplets of milk that are propelled from the short milk tube (inflation stem) back against the teat end as the liner opens and when cyclic and irregular vacuum fluctuations occur.

4. The impact force of milk droplets returning to the opening liner can implant contaminated milk in the teat canal. The chances of such contaminated milk being washed out by other milk is obviously reduced the nearer implantation occurs to the end of milking. Too, organisms implanted in the teat canal are out of reach of teat dips applied after milking.

5. It was further concluded that contaminated milk may be propelled through the teat canal and into the teat cavity where the chances of infection are greatly enhanced.

6. Impacts may be suppressed in three ways: (a) by using short milk tubes and claw nipples of very large bore in conjunction with a slow rate of re-evacuation of the pulsation chamber to reduce cyclic fluctuations in vacuum; (b) by bringing the short milk tube at an angle into the exit end of the liner or at such an angle of attachment as to prevent impact on the end of the teat; or (c) by providing a deflector device or shield near the exit end of the liner to intercept milk droplets returning from the short milk tube.

7. Extensive studies revealed that the use of shields reduced significantly the number of impacts as well as the number of new infections under research conditions.

8. Large-scale field trials are now underway in commercial dairy herds to test the value of shields in inflations for preventing machine-induced infections. Preliminary results indicate that the shields are working satisfactorily in some herds but not in others. Obviously, more research is needed to establish which herds are likely to benefit from the use of protective shields. It is a source of
encouragement, however, that some fundamental research is finally being conducted on milking machines and their relationship to udder health.

In summary, fluctuations in vacuum should be minimized by having the milking machines checked by a qualified serviceman at least twice a year. Any observed deficiencies in machine function should be corrected immediately. Also, the teat cups should be removed from the udder as soon as milk flow ceases in order to prevent many machine-induced infections.

**Role of Vaccination.** Vaccination against the common mastitis pathogens has been of little value in reducing the incidence of new infections. It may be of some value in specific herds for reducing the severity of clinical cases but will not affect the incidence of clinical cases.

**Elimination of Infection**

Once infection occurs, it can be eliminated only by spontaneous recovery, culling, or therapy. These methods are discussed separately.

**Spontaneous Recovery.** Approximately 20% of all streptococcal and staphylococcal infections are eliminated in this way; however, most spontaneous recoveries occur in quarters with mild or recent infections and only rarely in the case of well-established infections. A greater proportion of streptococcal infections (24%) disappears by spontaneous recovery in the dry period than of staphylococcal infections (8%).

The mechanism of spontaneous recovery appears to be independent of the natural defense mechanisms which prevent the establishment of new infections. Since we do not understand the mechanism of action here we cannot capitalize on spontaneous recovery as a means of eliminating infection.

**Culling.** Culling is often the only practical means of eliminating chronic infections from a herd. There are obvious economic limits, however, to the proportion of cows that can be culled due to clinical mastitis. In one extensive study, it was revealed that only 7% of the cows account for 40% of all clinical mastitis. This level of culling is probably acceptable for most herds and would remove a primary source of mastitis pathogens from the premise as well as a substantial percentage of the clinical cases.

**Therapy.** It has been shown that both spontaneous recovery and culling have serious limitations in terms of utility for reducing the duration of infections. It has also been shown that if a mastitis control system is to reduce infection to low levels in months rather than years, it is necessary to treat subclinical as well as clinical mastitis. Probably, the best time to accomplish this is at drying off. Treatment at drying off has the following advantages: the efficacy
of treatment is higher than when administered during lactation; high-persistence antibiotic formulations may be used; the number of infections that occur during the dry period is reduced significantly; damaged tissue may be regenerated before freshening; clinical mastitis at freshening is reduced by up to 90%; and salable milk is not contaminated.

Most programs for treating dry cows call for treating all quarters of all cows at drying off with a specially formulated, high-persistence antibiotic formulation. Some workers feel that only selected quarters should be treated in herds with a low level of mastitis. In such instances, treatment is limited to cows with a clinical history, or those positive to the California Mastitis Test during the last month of lactation.

The prognosis regarding effective treatment of S. agalactiae mastitis is excellent because the organism is an obligate parasite of the bovine udder, a low-grade pathogen, highly sensitive to penicillin; and a normal inhabitant of the milk ducts of the udder where it can be reached by drugs. In most herds a single infusion of 100,000 units of penicillin will result in the elimination of approximately 90% of the infections due to S. agalactiae. Larger doses of penicillin are seldom, if ever, needed in the treatment of S. agalactiae mastitis. This organism can be eradicated from a dairy herd by repeatedly culturing milk samples from each cow and treating all infected quarters. Other strains of streptococci often cause a more severe type of mastitis than S. agalactiae and effective treatment is more difficult.

The likelihood of effective treatment of staphylococcal mastitis is low. Many strains of staphylococci secrete toxins which enable the organisms to readily penetrate the duct walls of the udder where they become established in numerous foci that are walled off with fibrous tissue, thus creating a habitat virtually impenetrable by drugs.

The ability of some staphylococci to develop resistance to antibiotics is well-known. It appears, however, that tissue barriers formed within the udder as a result of the presence of the organisms are of much greater importance in therapeutic failures than the matter of drug resistance. As a general rule, a treatment efficacy of only about 50% can be expected from the treatment of subclinical staphylococcal infections. The efficacy will be much lower in instances of well-established infections. A study in Louisiana showed that the efficacy of treatment was 68, 67, 28, and 13% for staphylococci-infected quarters producing milk with California test scores of 0, 1, 2, and 3, respectively.

Sensitivity Tests. Drug sensitivity tests should be conducted on all organisms cultured from quarters with acute or clinical mastitis. A high percentage of the organisms involved in such cases are usually resistant to one or more of the commonly-used therapeutic agents. It is not necessary, however, to conduct sensitivity tests on all isolates from quarters with subclinical mastitis because only
a small percentage of these organisms have been found to be resistant to the commonly-used drugs. While sensitivity testing provided the best guide to the selection of an effective therapeutic agent for treatment against a particular organism, successful treatment depends upon the antibiotic diffusing to all sites of infection within the udder in sufficient concentration to kill all the organisms present.

Drug Residues. Prevention of drug residues in milk is critically important. Milk should be discarded in strict accordance with the instructions on the label of any therapeutic agent used.

ECONOMICS

Practically every person who has any association with the dairy cow is familiar with the clinical manifestations of mastitis. Unfortunately, only a relative few appreciate the prevalence and economic significance of the subclinical form. Subclinical mastitis is important because it is 15 to 40 times more prevalent than the clinical form, usually precedes the clinical form, is of long duration and difficult to detect, reduces milk production, and adversely affects the quality of milk. Thus, in efforts to abate mastitis, emphasis should be focused on the subclinical disease.

Money Losses. Research conducted by numerous researchers has documented the high cost of mastitis. The losses are divided as follows:

Death and premature culling------------------14%
Milk discarded-----------------------------8%
Treatment and veterinary expenses-----------8%
Reduced milk production---------------------70%

These figures confirm that the greatest losses result from a decrease in milk production from subclinically affected animals. Indeed, work in Louisiana revealed an average loss of 46% in milk production from quarters which were shown to harbor subclinical infections and which yielded a California Mastitis Test score of 3. In each case, the milk was visibly normal and the presence of the disease would not have been recognized by dairy farmers.

Recent research conducted at Cornell University revealed that milk losses from a single infected quarter averaged 1,700 pounds per lactation. In other words, a single infection resulted in a milk loss of well over 100 dollars per year.

A close correlation also exists between lost herd milk production and the number of somatic cells present in bulk tank milk. Most herd milk contains between 500,000 and 1,000,000 somatic cells per milliliter. Yet, such herds are losing an average of 12% in milk production. These figures again translate to losses in excess of 100 dollars per cow annually.
Response From a Control System. Large scale field trials conducted in the U.S. and abroad have measured the effect on level of infection of dipping teats immediately after milking with an effective teat dip and treating each quarter at drying off with a specially-formulated antibiotic preparation. These simple procedures were shown to be highly effective. The level of infection in the commercial herds was reduced by 50% within 1 year and 75 to 85% within 2 to 3 years. In addition, the somatic cell content of the bulk tank milk decreased from 730,000 to 320,000 over a 3-year period and the incidence of clinical mastitis declined at least 40%.

Money Returns. The significant reductions in level of infection were accompanied by an increase in herd milk production of more than 1,000 pounds per cow annually. At current milk prices this amounts to an increased yearly income of approximately 100 dollars per cow from following the simple and effective control procedures. The total cost of the program, i.e., teat dip, antibiotic treatment tubes, and extra labor, amounted to less than 15 dollars per cow per year. This left a net profit of about 85 dollars per cow. Another way of viewing these figures is that the dairy farmer realized 5 to 7 dollars in return for every dollar invested in the control program.

Herds with a high level of infection obviously stand to realize greater profits than herds with a low level. Nevertheless, the implementation of an effective mastitis control program is a wise and prudent decision. The challenge to everyone in the dairy industry is to try to achieve greater implementation of these effective mastitis control methods on dairy farms.

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