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Developing Strategies To Reduce Mastitis
Caused By Environmental Streptococci

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Contagious mastitis has been successfully controlled by herds implementing the Five Point Plan of the National Mastitis Council. This program has not proven effective against intramammary infections (IMI) caused by environmental streptococci and coliforms. A new approach is needed.

Methods of diagnosing, treating and preventing IMI caused by *Streptococcus agalactiae* have been well established by research and field experience. Similarly, although a more complicated disease, much is known about *Staphylococcus aureus* mastitis. Procedures such as post-milking teat disinfection and antibiotic treatment of all cows at the end of lactation, can be confidently recommended to producers to control these pathogens. They have been shown to produce consistent results in a wide variety of herd situations, provided they are correctly and completely implemented. Failure to keep mastitis caused by these two pathogens at an acceptable level is often a surrogate measure of the herd manager's skill and dedication, rather than a failure of the recommended control program.

Environmental mastitis, IMI with environmental streptococci (ES) and coliform bacteria, has proven to be more complex and frustrating. Producers have implemented traditional mastitis control programs yet their herds have continued to have new mastitis infections. Frequently these IMI are clinical, appearing to the herd owner to reflect an increased problem with mastitis even though herd and cow SCCs are low. Diagnosing the bacterial cause of mastitis in these types of herds can be difficult as ES and *E. coli* IMI are often of short duration. Negative milk culture results from cows with obvious clinical signs of mastitis can be common. The timing of peak bacterial numbers may only briefly coincide with clinical signs. Adequate numbers of appropriate samples are often difficult to obtain. Ultimately, the recommendations made are tentative, and an objective assessment of their impact is difficult to conduct.

Researchers and herd advisors have sought recommendations, as explicit as those in the 5 point plan for contagious mastitis, to prevent and treat environmental mastitis. However, because of the complexity of the factors that interact to cause environmental mastitis, it is unlikely that set, specific procedures will work under all conditions in all herds. Instead, it may be more appropriate to develop a standard problem-solving approach for herd mastitis problems associated with ES. Such an approach would ensure that all relevant areas and factors that could relate to the problem are examined, and that herd-specific solutions are implemented.

Epidemiological Diagnostic Procedure

Herds with mastitis problems caused by ES seek help for two main reasons. A persistently elevated bulk milk SCC may be a problem because of the owner's desire to reduce mastitis, or because SCC regulatory limits are exceeded. An increased rate of clinical cases may also trigger an investigation. This latter situation will be increasingly detected as herds improve record keeping and use herd management software to monitor rates of disease. The clinical case rate may be perceived as too high in comparison to the herd owner's desires for performance, or to some benchmark derived from regionally collected data.

In either situation, it is necessary to have a standardized investigative approach which can be applied to any herd. The application of basic epidemiological diagnostic principles, using clinical observations, laboratory data and information gathered from records and on-farm investigation can prove useful.

According to Schwabe the basic epidemiological diagnostic procedure is a:

"measurement of frequency and patterns of occurrence of diseases and their possible determinants, with analysis for probabilities of causal associations." (17)

Epidemiologic diagnosis of ES mastitis problems can be simplified by answering the questions described below, using all available information about the problem. Information to collect includes:

- a cow inventory listing the current lactation number and most recent calving date for each animal;
- individual cow SCCs and milk production data;
- clinical case records;
- milk culture results;
- bulk milk SCC results for at least one year, and
- observations from environment and milking time inspection.

The Process

What is the mastitis problem?

Clinical case records and individual cow SCCs are used to describe the mastitis problem as predominantly clinical or subclinical. A milk sampling protocol, appropriate for the type and prevalence of the mastitis problem suspected, is designed. The historical rate of new mastitis cases is used to estimate the duration of the time period needed for sample collection. Sufficient cases are needed to provide information from which valid conclusions can be drawn. Milk samples from affected cows are submitted to the diagnostic laboratory for bacterial culture.

Collection of composite samples from the entire herd at one time, termed herd survey culturing, is appropriate if a large proportion of the herd has elevated SCCs on a single monthly DHI test. If only a few animals have persistently elevated SCCs then only these animals should be sampled by a single time survey. In most situations all clinical cases should be sampled as they occur because the bacterial cause of a given case cannot be determined from changes in the milk, udder or the cow (20). Milk samples from clinical quarters can be frozen until a number are collected to reduce laboratory and transportation costs (5).

Mastitis infections caused by ES can be of very short or very long duration. In one herd 36% lasted less than 10 days, 59% lasted less than 30 days and the geometric mean of days infected was 17 (19). In another herd researchers found the average duration of a clinical mastitis case to be 6.6 days (14). Frequently, herds affected by ES have "spiking" individual cow SCCs or report high clinical case treatment rates even though cow SCCs are rarely elevated on the monthly DHI test. This occurs because monthly SCC tests detect only a portion of short duration mastitis cases. To maximize the diagnostic sensitivity of milk culture, samples from clinical cases must be collected as soon as clinical signs are noticed. Sampling based on monthly SCCs in ES herds results in many false negative culture tests as the timing of the monthly SCC test will not necessarily coincide with peak bacterial numbers in all cow infections.

The equation "*Prevalence = Incidence x Duration*" is useful in describing the dynamics of ES infections (13). According to this relationship the number of mastitis cases in the herd at one point in time (prevalence) depends on how many new infections occur (incidence) and how long they last (duration).

ES mastitis problems can be categorized as either a high prevalence or high incidence pattern using information from SCC, clinical case and culture records. In high prevalence herds the new infection rate is relatively low but the infections that occur are of long duration, resulting in an accumulation of infected cows in the herd. High prevalence ES herds may have continuously elevated bulk milk SCCs similar to those of herds with a high prevalence of contagious mastitis infections. Examination of the herd at a single time point may be sufficient to describe this high prevalence pattern of disease and the bacterial cause of most of the infections.

Indeed these herds may appear to behave like contagious mastitis because the ES infections are of such long duration that spread may be occurring at milking time in a fashion similar to the pathogens commonly classed as contagious, *Staph. aureus* and *Strep ag.* Mastitis spreads at milking time because milk containing bacteria is transferred from an infected cow to the udder of an uninfected cow. Provided these bacteria can adhere to skin or are aided in some fashion to enter the new quarter a new infection occurs. *Staph. aureus* and *Strep. ag* .are contagious because, typically, infections with these two bacteria persist for a long time. If ES infections persist for long periods of time (ie. greater than 30 days) then the risk of the infected cow spreading the infection to an uninfected cow is greatly increased. The cow shedding ES bacteria in her milk for 30 days instead of 6 to 7 days gets many more Achances@ to cause new ES infections in herd-mates at milking time.

Differences in the duration of ES infections have been recognized (10). Factors that influence the duration of ES infections, and hence the Aspreadability@ of the ES have not been clearly defined. They may related to characteristics of the bacterium itself, the cow or the herd.

Bacterial factors suggested include the type of ES bacteria. Infections caused by different strains of *Strep uberis* have been shown to differ in their ability to resist some host defence factors (12). Resistance to removal will affect the duration of infection.

Extrapolation from work done with other mastitis causing bacteria suggests that the duration and severity of the ES infection will be modified by cow factors such as the cow or udder=s immune status, the stage of lactation, age, nutritional status and concurrent disease problems (19). For example, mastitis caused by *E. coli* has been shown experimentally to be more severe in ketonemic cows in comparison to non-ketonemic cows (11).

Superimposed on these and other individual cow characteristics are herd factors which also can impact on the duration of infection. Housing facilities and management strategies can impact on cow stress and immune function and, in turn, the duration of ES infections. The frequency of milk quality testing will also be a herd factor that will affect the apparent duration of ES infections. If SCC testing occurs monthly many short duration infections will not be detected and infection duration will essentially be measured in monthly units.

Little information is currently available which describes cow or herd factors which affect the duration or persistance of ES infections. Multi-herd studies, including cows with ES are needed to clarify these suspected herd and cow differences.

In high incidence herds many cows become infected over a given time period, but because infections are of short duration, only a few are infected on any given day. Continuous monitoring by frequent SCCs, culture, or more practically, the recording of clinical cases, is needed to accurately describe herds with this high incidence disease pattern.

In some cases very high incidence herds may on initial inspection, be misclassified as high prevalence herds. In these situations individual cow monthly SCCs, and consequently herd average SCCs as well, are continuously elevated suggesting continuous, chronic infection. DHI SCCs are composite samples and therefore give no information about the number or identity of high SCC quarters. Closer examination of selected cows is needed to determine whether one quarter is persistently infected or if many infections are occurring repeatedly in different quarters.

High incidence herds may have high, low or fluctuating bulk milk SCCs depending on the timing of the bulk milk sampling in relationship to the number of cows infected on that particular day. Fluctuations, particularly in small herds tested monthly, can be marked. Monthly bulk milk and cow SCCs are inadequate for quantifying and monitoring ES mastitis (9). More frequent SCC determinations or the more frequent use of other tests for inflammation can give a better indication of the number of cows infected and the underlying pattern of disease .

Categorizing the pattern of ES mastitis as either high prevalence or high incidence must be done early in the herd investigation. Ultimately it will determine whether the recommendations made will emphasize measures which shorten the duration of infection, as would be appropriate in high prevalence herds, or include measures aimed at reducing the new infection rate, the best action for high incidence herds.

Who **has mastitis?**

Individual cow SCCs and clinical case records are used to identify affected animals. The frequency of cases among animals of different parity and different stages of lactation is tabulated.

Case counts by lactation number help to identify management practises that differ among age cohorts. For example, pre-calving environments, nutritional programs and therapy usually differ between heifers and cows and may influence the risk of mastitis. Other age differences also occur. Older cows, because of increased size, and longer lifetime exposure to the lactating cow environment, may be more prone to teat injury and milk leakage. It has been suggested that cows leaking milk at dry off time have a four times greater risk of a clinical case of mastitis during the dry period (16). Different mastitis rates in different parity groups also can reflect historic differences in housing, bedding, therapy or milking systems.

The case rate by stage of lactation is tabulated to assess the impact of the lactating, dry cow and calving environments and management. Emphasis should be placed on estimating the impact of the dry period on new ES IMI. In one detailed herd study, about half of all ES infections occurred in the first 76 days of lactation, and about half of these originated in the dry period (19). In another closely monitored herd, 87% of new IMI occurred in the dry period or within the first 7 days after calving (8). If, as shown in these previous studies of two herds, early lactation is a time of increased risk of new ES cases, dry cow housing, treatment, nutrition and management of the cow at calving time should be closely examined. Similarly, the clustering of new IMI cases within a particular stage of lactation may point towards specific environmental and management risk factors.

The earliest cow SCC test that can reliably be used to identify mastitis, is generally reported more at than 15 days post-calving (1). The result of this test gives little information about IMI occurring during the peri-parturient period, a time of high risk for ES infections. Case recording by the producer is essential to separate risk factors affecting dry cows from those occurring during lactation. Additional tests, such as the California Mastitis Test (CMT), can be used to collect specific data on mastitis rates immediately after calving or during the time preceding the first DHI SCC test. Although CMT results may be affected by the presence of colostrum and other physiological factors in very early lactation the test should be assessed as a "within-cow" test for the probability of mastitis. Rather than comparing test results to a standardized chart, changes in the milk reaction should be examined for one or two quarters that are significantly different than the rest and therefore are more likely to have infection rather that just colostrum. CMT results should be recorded as a monitor of mastitis originating during the dry or peri-parturient periods, or from the previous lactation. Milk samples, collected at the same time as the CMT, can be frozen and submitted later for culture as a historical record of fresh cow mastitis. Additionally specific pathogens can be identified which will help to target the recommendations for prevention and treatment.

When **and** ***where*** **is mastitis occurring?**

Records of clinical cases and SCCs can be used to determine where on the farm or in the housing system cows are most at risk of new ES IMI. On-farm investigation and careful observation can detect factors likely to be associated with mastitis.

Both external and internal farm climates can affect ES mastitis. Unfortunately few quantitative studies exist examining the impact of seasonal factors on ES mastitis rates. Seasonal changes in temperature and humidity, have been shown to affect the rate of ES and clinical mastitis (3, 15, 19). Annual periods of high risk can be determined by examining the rate of new ES or clinical mastitis infections that occur monthly. In one study of a farm in Ohio the rate of ES infections was elevated in the summer and fall (19). In UK studies, infection rate was highest during the winter stabling period (3). Recognition of times of high risk can lead to the development of proactive strategies to moderate this effect.

Examination of areas on the farm associated with an increased rate of new ES IMI will identify internal farm climates that lead to problems. Uneven calving rates, the birth of a high proportion of heifers, or low production are examples of changes that can temporarily increase the animal density within certain environments. Producers often fail to recognize the potential impact of these changes on environmental bacterial numbers and exposure of the herd to an increased risk of ES mastitis.

Proper housing management should reduce the concentration and multiplication of ES in the environment. Improved ventilation can reduce temperature and humidity. Bedding hygiene and types also have been shown to impact on ES mastitis (4, 10, 19). Differences in mastitis rates between milking groups, certain housing areas, stalls of differing dimensions or associated with different milking personnel may be found. Closer examination of factors associated with the problem location is warranted. Sometimes the final cause of mastitis is not found but a solution to the problem becomes obvious.

What **"caused" the mastitis problem?**

The presence of ES in the cow's environment is likely a necessary cause of ES mastitis as no other sources of bacteria have been identified. However, simply having the bacteria present does not always cause mastitis. A variety of other factors, present at the bacterial, cow and herd levels which affect bacterial numbers in the environment, exposure of the teat end and the resistance of the cow are also important. Intervention to prevent ES mastitis involves manipulation of one or more of these component causes.

Clearly ES mastitis is a multi-factorial disease, where very few of the significant factors have yet been identified. Not only is more than one factor likely important in outbreaks, but combinations and interactions of factors are likely also potential mediators of mastitis. The effect of one factor may be relatively clear on one farm, yet of different importance on another. For example, two herds may have a high rate of liner slips at milking time, a factor shown to be associated with a higher prevalence of ES mastitis (2), yet one herd will have an ES problem and the other will not. The negative effect of liner slips will be increased in herds with high numbers of ES bacteria in the environment and a greater exposure of teat ends. Accordingly though, herds with good bedding management and adequate ventilation may not find liner slips to be as important a risk factor for ES mastitis.

Predipping, the dipping of teats with disinfectant before milking, has been shown to reduce the incidence of ES infections (6). Yet further studies suggest this beneficial effect is not seen in all herds (18). Herds with poor milking time hygiene that are inadequately cleaning and drying teats may have an increased risk of ES infection associated with milking time and lactation. Adopting pre-dipping is suggested to improve this. However herds with ES infections attributable to poor peri-parturient hygiene will not benefit adopting rom this management practise. Determining the specific pattern of disease is essential for predicting the appropriate changes or practises to implement.

Epidemics or outbreaks of ES mastitis may be associated with the presence of a variety of interacting factors of varying importance. Once the factors have "loaded" or burdened the cows resistance, seemingly very minor factors may tip the balance in favour of an outbreak. Epidemics are not linear. The "tipping point", the point at which an ordinary and stable phenomenon becomes an epidemic may be difficult to determine and may be relatively unique for each premise and situation. Every epidemic has it's tipping point and to fight an epidemic effectively you need to understand what that point is (7). The importance of various factors predisposing to epidemics of ES mastitis are not equal. Therefore the removal or improvement in some aspects of management associated with mastitis may not bring entirely predictable results.

Why **did mastitis occur?**

Clinical case records, laboratory and other testing data are analyzed to define the problem as described above. A simple hypothesis about why mastitis is occurring is generated. If herd size and case numbers are large enough factors suspected of contributing to the problem can be statistically tested to verify their relationship to mastitis. Formal evaluation establishes that the difference observed is unlikely to have occurred due to chance alone.

How **is the mastitis problem controlled or prevented?**

Once factors suspected of causing ES mastitis are identified, recommendations are made to provide solutions. They must be specific to the current problem, few in number and clearly explained to maximize compliance. Recommendations are ranked in priority based on the overall importance attributed to changing that factor and on the ease and timeliness with which the change can be made.

Often there will be short and long term recommendations. For example, if new IMI's are occurring at calving time, it may be recommended to calve cows temporarily in a driving shed or outside on pasture. The long term recommendation would be to increase the number of

maternity pens to accommodate the maximum number of expected calvings.
In high prevalence herds, shortening the duration of existing infections is emphasized. If the bulk milk SCC is close to penalty levels treating affected lactating cows identified from SCC and culture reports would be critical. Drying cows off prematurely and treating with dry cow antibiotic products could also help, if economics allowed their removal from the bulk tank. In less pressing situations ensuring all cows receive dry cow antibiotic treatment at the end of lactation will cure 84 to 100 % of ES infections (3,8) and reduce the prevalence at the following calving (19,21).

In high incidence herds strong emphasis is placed on recommendations which reduce the new IMI rate. These recommendations are highly herd and situation specific. Lactational and dry cow treatment with antibiotic may be of little use in these herds. As rapidly as existing infections are removed, new ones start.

To evaluate the effectiveness of the changes recommended appropriate monitoring measures should be selected. For example, if dry cow treatment is implemented, data on clinical cases and CMT evaluations post-calving, should be collected started with cows calving two months after the new treatment is implemented. The evaluation should continue until enough cows have calved to prove the usefulness of the change.

Summary

Traditional mastitis monitoring and control programs have focused on contagious mastitis. However, as the prevalence of contagious pathogens in many jurisdictions declines, ES mastitis is assuming greater importance. Strategies for ES mastitis prevention, that work in concert with current housing and management systems, have yet to be developed and tested in field situations.

Epidemiological diagnosis using the questions described above, offers a logical and rational process for the investigation of herd ES problems. Ultimately, herd specific solutions are created. Producer compliance is maximized because these programs relate to the individual's herd, farm environment and the current problem.

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