A Practical Look at Environmental Mastitis

K. Larry Smith, *D.V.M.*
Department of Dairy Science
The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio 44691

Introduction

The bacterial genera and species most frequently associated with bovine mastitis can be divided into two large groups based on the primary reservoir of the bacteria in a dairy herd for infection of the uninfected quarter. These two groups are the contagious pathogens and the environmental pathogens. The primary contagious pathogens are *Streptococcus agalactiae* and *Staphylococcus aureus.* The environmental pathogens are composed of two large groups of bacteria, and they are coliform bacteria and species of streptococci other than *Str. agalactiae.* These streptococci are referred to as the environmental streptococci.

The primary reservoir of the environmental pathogens is the environment in which the cow lives and not the infected mammary quarter. This is in contrast to the contagious pathogens. The differing primary reservoir results in vastly differing dynamics of infection or mastitis in dairy herds and explains to a great extent why methods of control developed for the contagious pathogens are not effective against the environmental pathogens.

Presently, there is no single uniform method of control for the environmental pathogens that has been shown effective under controlled conditions. The following material will attempt to provide information on the general characteristics of environmental pathogens, their relationship to the environment, and finally, the positive or negative aspects of specific methods of mastitis control for the environmental pathogens.

General Characteristics

A. *The Environmental Streptococci.* The environmental streptococci include *Str. uberis, Str. bovis, Str. faecalis, Str. dysgalactiae, Streptococcus spp.,* and the enterococci. They are sometimes referred to as the esculin positive streptococci, but many strains of *Str. dyscalactiae* are esculin negative. In some publications, all esculin positive streptococci have been referred to as *Str. uberis,* but they are clearly not all *Str. uberis.*

1. *Detection by Culture of Milk.* These streptococci are reliably cultured from the milk of infected quarters by platting .01 ml of milk on esculin blood agar. CFU/ml is generally greater than 100 in milk from infected quarters.
2. *Diagnosis of an Intramammary Infection (IMI).* Isolation from a milk sample does not necessarily indicate IMI as isolation could have resulted from contamination. Composite milk samples will greatly complicate diagnosis.
3. *Rate of IMI.* Rate of IMI (new infections/cow-day) is higher during the dry period than during lactation. In the absence of dry cow therapy, rate of IMI will increase dramatically during the first 2 weeks of the dry period. Rate of IMI is again elevated during the 2 weeks prior to calving. Rate of IMI during the dry period will increase as parity increases.

   During lactation, rate of IMI is highest during early lactation and decreases progressively as lactation advances. The decline across lactation is not as great as that observed for coliform rate of IMI. Rate increases progressively as parity increases.
4. *Duration of IMI.* Infections are of shorter duration than those caused by *Str. agalactiae,* but of longer duration than coliform IMI. Fifty-nine percent are less than 30 days duration, but approximately 18% become chronic and are present for greater than 100 days. Approximately 39% of IMI present in lactation will be eliminated spontaneously.
5. *Prevalence of IMI.* The percent quarters infected at any one point in time in a dairy herd is generally low by comparison to the contagious pathogens and seldom exceeds 10% of quarters.
6. *Herd Monitoring Methods.* Attempting to assess the impact of the environmental streptococci in a dairy herd is poorly achieved by: a) bulk tank somatic cell counts; b) individual cow somatic cell counts at monthly intervals; c) culturing cows at monthly or semiannual intervals; d) culturing only a sub-population of cows; e) culturing bulk tank milk. Accurate records of the incidence of clinical mastitis, together with cultures of milk from clinical quarters, will help assess the impact of the environmental streptococci in herd mastitis.
7. *Clinical Symptoms.* Approximately 50% of these IMI present in lactation will cause clinical mastitis. Clinical cases are generally associated with clotty or flaky milk, little or moderate swelling of quarters, and are seldom associated with systemic symptoms.

Paper presented at the Quality Milk Course for Veterinarians, at Ohio State University, March 25-26, 1986.

8. Antibiotics approved for use in lactating dairy cows are less effective by comparison to *Str. agalactiae.* Cure rates following therapy during lactation are generally in the order of 50-60%. Dry cow therapy eliminates the majority of infections present at drying off and significantly reduces the rate of new IMI during the first 2 weeks of the dry period. However, there is no effect on rate of IMI during the 2 weeks prior to calving.
9. *Eradication from a Dairy Herd.* In contrast to the contagious pathogens, the environmental streptococci cannot be eradicated from a dairy herd.

B. *Coliform Bacteria.* The coliform bacteria involved in mastitis are a heterogenous group of genera and species and include *Escherichia coli, Klebsiella pneumonia, Klebsiella oxytoca, Enterobacter aerogenes,* and a wide number of other gram negative rods including the genera Citrobacter, Serratia, Proteus, Hafnia, etc.

1. *Detection by Culture of Milk.* The coliform bacteria are not reliably cultured from milk of infected quarters by streaking .01 ml of milk on esculin blood agar. Colony Forming Units (CFU) per ml are frequently less than 100 CFU/ml or below the minimum detection limit of the method. We routinely streak .01 ml on esculin blood agar and .1 ml on ½ plate of MacConkey Agar. Detection is further complicated by composite milk samples.
2. *Diagnosis of Intramammary Infection.* Isolation from a milk sample may have been as a result of contamination. On the other hand, isolation of 1-5 colonies cannot necessarily be disregarded as contamination. Mixed infections do occur, and the most frequent coliform mixed IMI in our herd is a coliform plus one of the environmental streptococci. Mixed coliform IMI can occur, and we have positively identified infections involving an *E coli* and a *Klebsiella spp.* Diagnosis of IMI is improved by duplicate quarter samples or isolation from 2 of 3 consecutive samples.
3. *Rate of IMI.* For a given level of exposure (same housing conditions for dry and lactating cows), rate of IMI (IMI/cow-day) is approximately 4 times greater during the dry period than during lactation. Rate of IMI is not constant across the dry period, but markedly elevated during the first two weeks and the two weeks prior to calving. Coliform IMI new in the early dry period and persisting to lactation are generally other than *E. coli. E. coli* IMI new in the dry period and present in lactation are highly likely to have originated in the period around calving. Rate of IMI during the dry period will increase as parity (number of dry period) increases. Dry cows continuously housed will have lowest rates of IMI during winter months and highest during summer months.

   During lactation, rate of IMI is highest during early lactation and decreases progressively as lactation advances. Rate increases as parity increases. Rate will increase as the number of coliform bacteria in [illegible] materials increases and rate will be highest in summer months for continuously housed cows.
4. *Duration of IMI.* Coliform IMI tend to be of very short duration. Fifty-seven percent are less than 10 days duration and 69% are less than 30 days duration. Chronic coliform infection can occur and 13% will exceed 100 days duration. Chronic coliform IMI are highly likely to be other than *E. coli* and only 1.5% of *E. coli* IMI exceed 100 days duration.
5. *Prevalence of IMI.* The percent quarters infected at any one point in time is generally very low, and 2-4% of quarters infected at any one point in time is a high prevalence of coliform IMI. Typically, one finds 1% or less of quarters infected, but the coliform bacteria may be responsible for 30-40% of clinical mastitis cases. Prevalence may be highest during the summer months for continously housed cows and prevalence will likely increase during periods of frequent calvings.
6. *Herd Monitoring Methods.* Attempting to assess the impact of the coliform bacteria in a dairy herd is poorly achieved by: a) bulk tank somatic cell counts; b) individual cow somatic cell counts at monthly intervals; 3) culturing cows at monthly or semiannual intervals; d) culturing only a subpopulation of cows; or 3) culturing bulk tank milk. Accurate records of the incidence of new clinical cases of mastitis, together with culture of milk from clinical quarters, will help assess the impact of coliform bacteria in herd mastitis.
7. *Clinical Symptoms.* Eighty to 90% of coliform IMI present in lactation will result in clinical mastitis. Only 8-10% of coliform IMI present in lactation will result in peracute mastitis. The majority of coliform clinical cases will be associated with clotty or flaky milk and no to moderate swelling of quarters. Research has shown that *E. coli* can grow to easily detectable numbers and subsequently be eliminated by phagocytic cells before visible symptoms of clinical mastitis occur. We have never observed a chronically infected quarter that suddenly progressed to peracute mastitis. Peracute mastitis is most frequent in older cows, in early lactation, or during periods of persistent hot, humid weather, particularly when conditions are associated with violent thunderstorms. My opinion is that peracute coliform mastitis is nearly always associated with a "stressor" applied to the cow, and that the development of peracute symptms is most likely a function of the cow and not a particularly "hot" coliform strain.
8. *Antibiotics.* Antibiotics approved for use in lactating dairy cows are uniformly ineffective against the coliform bacteria. Cure rates following lactational therapy are in the order of 20% for all coliform IMI. However, cure rates for *E. coli* are in the order of 50%, but spontaneous cure is also in the order of 50%. Presumed discovery of an effective product against *E. coli* should be viewed with great caution.

Products currently formulated for use in dry cow therapy are of little value for control of coliform IMI during the dry period.

9. *Eradication from a Dairy Herd.* The coliform bacteria cannot be eradicated from a dairy herd.

The Environment

Housed cows are at greater risk of environmental mastitis than cows on pasture. Sources of the environmental pathogen include feces, urine, bedding materials, feedstuffs, dust, dirt, mud, water, birds, rodents, and dust webs. Bedding materials are a frequent and significant source of teat end exposure to the environmental pathogens. A general guideline is that bedding coliform populations exceeding 1 million per gram of bedding are very likely to contribute to a coliform mastitis problem. No such guidelines have been established for the environmental streptococci.

Finely chopped organic bedding materials such as sawdust, shavings, recycled manure, pelleted corn cobs, peanut hulls, chopped straw, etc., frequently contain coliform and streptococcal numbers in excess of one million and may exceed 100 million per gram. Clean long straw generally has coliform numbers less than one million, but exposure to the environmental streptococci may be elevated. Inorganic materials such as sand or crushed limestone are preferable to finely chopped organic materials.

Attempts to maintain low coliform numbers in organic bedding materials by application of chemical disinfectants or lime are generally not practical as frequent, it not daily, application is required to achieve results. Daily total replacement of sawdust bedding in the back 1/3 of stalls has been shown to reduce exposure of teat ends to coliform bacteria. There are frequent reports of an association between sawdust bedding and increased Klebsiella mastitis. However, high numbers of other coliform types and the environmental streptococci are frequently found in sawdust bedding.

Organic bedding materials generally have low coliform and streptococcal populations when placed under the cows. However, they are quickly contaminated by the environment and cows, and numbers of bacteria per gram are generally very high within 24 hours. The appearance of bedding can be very misleading with regard to the actual coliform contamination. Numbers are frequently higher in clean appearing sawdust than in heavily used and soiled sawdust.

Number of bacteria in a given bedding material will fluctuate depending upon degree of contamination, availability of nutrients in the material, the amount of moisture available, and the temperature. In general, drier bedding materials are associated with lower number of pathogens. Warmer environmental temperatures favor growth of pathogens and lower temperatures tend to reduce growth. In general, damp, humid and wet conditions in the environment of a dairy herd will likely increase exposure to environmental pathogens, and within these conditions, increasing temperature will aggravate the problem.

Other environmental conditions which may increase exposure include:

a) overcrowding
b) poor ventilation
c) inadequate manure removal from the backs of stalls, alleyways, feeding areas, exercise lots, etc.
d) poorly maintained (hollowed out) free stalls
e) cow access to farm ponds or muddy exercise lots
f) a general lack of farm cleanliness and sanitation

Control

Fundamental is the concept that mastitis control will most likely be achieved by either decreasing the exposure of teat ends to potential pathogens or increasing the resistance of cows to mastitis pathogens. Nearly all progress made in mastitis control has been as a result of decreasing the exposure of teat ends to pathogens.

1. *Teat Dipping - Germicidal Dips.* A degree of control is exerted against the environmental streptococci, but there is no control of coliform IMI. Teat dipping with germicidal dips is recommended. Teat dippers should be thoroughly washed and dried after each milking.
2. *Teat Dipping - Barrier Dips.* Barrier dips are reported to reduce new coliform IMI. Their efficacy against the environmental streptococci and the contagious pathogens appears not to be as great as germicidal dips. Barrier dips increase the cost of teat dipping and increase labor and time to prepare udders for milking. The use of barrier dips may be recommended in some coliform problem herds.
3. *Teat Dipping - Dry Period.* Attempts to control new IMI caused by the environmental pathogens during the dry period with either germicidal or barrier dips have not been successful.
4. *Dry Cow Therapy.* Dry cow therapy will significantly help control new infection by the environmental streptococci during the early dry period, and dry cow therapy of all quarters of all cows is recommended. Dry cow therapy will not control new environmental streptococcal IMI in the period prior to calving, and dry cow therapy is of little or not value for control of coliform IMI. Reinfusion of antibiotics during the latter part of the dry period is of little or no value for control of environmental IMI.
5. *Backflushing.* Backflushing of the milking unit will not control environmental mastitis.
6. *Milking Machine Function.* Badly malfunctioning milking machines resulting in frequent liner slips and teat impacts will increase environmental mastitis.
7. *Udder Preparation.* Wet milking of cows will likely increase environmental mastitis. Teats should be clean

and dry prior to machine attachment. Washing of teats and not the udder is recommended. In parlors, minimize water usage and do not spray unit after attachment to the teats.

8. *Predipping.* Claims are made that predipping will reduce environmental mastitis by 50%. That there is a significant advantage beyond milking clean dry teats requires additional research. Control may be greater in herds where machine function is poor or in herds where cows' teats are heavily contaminated with environmental pathogens.
9. *Immunization.* There are no scientific reports showing successful control of environmental mastitis following immunization. There are likewise no reports of successful control following passive administration of antibodies.
10. *Intramammary Devices.* There are reports showing a significant reduction in environmental mastitis following placement of the abraded intramammary device into quarters. There are, however, technical problems and problems with loss of effectiveness after one lactation that would prevent recommendation at this time.
11. *Diets.* Diets of dairy cows deficient in vitamin E and selenium will result in increased incidence of environmental mastitis. We recommend that diets of Holstein dairy cows during the dry period be supplemented with 1000 mg/cow/day and 3 mg selenium/cow/day, and that 10 cc Muse (50 mg selenium) be injected 3 weeks prior to calving. During lactation, we recommend 400-600 mg vitamin E/cow/day and 6 mg selenium/cow/day.

    There are also claims that dietary supplementation with vitamin A will reduce mastitis. The potential effects on environmental mastitis are poorly documented.
12. *Management of the Environment.* Environments should be as dry and clean as possible and should be as free as possible from accumulated manure, mud, and pools of stagnant water (SEE: ENVIRONMENT). When dealing with environmental mastitis, the environment of the dry cow is as important as that of the lactating cow.

References

1. Smith, K. Larry, D.A. Todhunter, and P.S. Schoenberger. Environmental mastitis: Cause, Prevalence, Prevention. J. Dairy Sci. 68:1531, 1985. 2. Smith, K. Larry, D.A. Todhunter, and P.S. Schoenberger. Environmental pathogens and intramammary infection during the dry period. J. Dairy Sci. 68:402, 1985. 3. Eberhart, R.J., R.P. Natzke, F.H. S. Newbould, B. Nonnecke, and P.D. Thompson. Coliform mastitis - A review. J. Dairy Sci. 62:1, 1979. 4. Smith, K.L., J.H. Harrison, D.D. Hancock, D.A. Todhunter, and H.R. Conrad. Effect of vitamin E and selenium supplementation on incidence of clinical mastitis and duration of clinical symptoms. J. Dairy Sci. 67:1293, 1984. 5. Bramley, J. The control of coliform mastitis. Proc. 24th Annual Meeting Natl. Mastitis Council, p. 4, 1985.