THE EFFECT OF DRY COW THERAPY ON PREVENTION OF MASTITIS

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CHAPTER I

INTRODUCTION

Control of bovine mastitis has been widely studied in recent years. Control programs involving milking hygiene, sanitation, and dry cow treatment have been the primary modes of action in the elimination of mastitis and prevention of new infections.

Subclinical and clinical infections are causing substantial monetary losses annually to dairy producers in the United States. These losses are due to reduced milk production, altered milk composition, costs of drugs and therapy, culling and replacement heifers, and extra facilities for housing infected cows. Lowered milk production is responsible for approximately 70 percent of the annual loss.

Most herds are believed to have at least 50 percent of the cows infected with pathogenic bacteria in an average of two quarters per cow. *Staphylococcus aureus*, *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, and *Streptococcus uberis* are the causative agents in 97 percent of the infections, whereas gram negative microorganisms are responsible for one percent. These pathogens gain entry to the mammary gland by way of the streak canal, and further set up infections in the teat canal and gland cistern. Animals are more susceptible to infections in the first month of lactation and during the first three weeks of the dry period.

Milking hygiene reduces the major sources of contamination frequently present in dairy parlors. It lessens the spread of pathogenic organisms from cow to cow. Recommended procedures include (1) use of single service paper towels, (2) machine stripping, (3) sterilization of milking equipment, and (4) post-milking teat dipping. Use of a post-milking disinfectant teat dip has been found to reduce colonies of Micrococci, Streptococci, and Staphylococci on teats. Post-lactation disinfectant teat dips have been shown to eliminate and prevent colonies of pathogens on teat skin surfaces after the last milking of lactation. Although sanitation has been found effective in preventing some new infections, it is not effective in eliminating existing udder infections.

Antimicrobial therapy has been advocated for use in the dry period, because a greater proportion of existing infections are eliminated and new infections prevented than with lactation therapy. Dry cow treatment avoids losses from marketable milk, and damaged tissue is allowed to regenerate. Lactation therapy is used primarily for treating clinical infections during the lactation and has limited value in eliminating existing infections. During lactational treatment damaged tissue is not regenerated, and milk has to be discarded for a period of time.

Dry cow treatment of all quarters, whether negative or infected, should reduce the number of existing infections and prevent new infections prior to subsequent freshening. Dry cow treatment does not take the place of culling or improving management practices, because severely infected cows rarely respond to antimicrobial therapy. These severely infected cows with extensive palpable fibrosis will resist the penetration of all antimicrobial drugs.

The purpose of this study was to investigate the effects of therapy during the nonlactating period on preventing new infections in dairy cows under climatic and management conditions prevailing in the Southwest.

Additionally, a small scale study was conducted to investigate the effects of pre-freshening teat disinfection on preventing new infections in first calf heifers.

CHAPTER II

REVIEW OF LITERATURE

Economic Losses

Bovine mastitis is the single most important disease affecting the dairy industry. It causes substantial losses due to reduced milk yield, altered milk composition, cost of drugs and therapy, replacement heifers, and additional facilities needed for housing infected cows. Fincher (1963), Brown et al. (1965), Forster, Ashworth and Luedecke (1967), Philpot and Johns (1967), Roberts et al. (1969), Janzen (1970) and Miller (1973) reported an estimated annual economic loss in the United States from $225 million to $1.081 billion or $23 to $70 per cow. The development of a mastitis control program to reduce annual loss sustained through mastitis would be inefficient if the cost of drugs and therapy equaled the money lost from the disease. Therefore, an economically sound mastitis control program must (1) cost less than the losses sustained by the disease, (2) be practical under a range of different conditions and (3) be efficient in eliminating and preventing clinical cases occurring during the lactation and dry period (Dodd et al. 1969).

Effect on Milk Production

Subclinical and clinical mastitis cause reduced milk yield during the lactation. Bacteria invade the mammary gland, destroy a portion of the secretory cells and cause the infected cow to produce below expected levels. Comparing the average milk production between opposite non-infected and infected quarters (two fore and two hind), based on positive reactions to various indirect tests, Shaw and Beam (1935) reported that the infected quarters produced an average 0.45 kg. (32.3 percent) less than the non-infected quarters. Rako, Okljesa and Jakovac (1962) reported a decrease in milk yield of 15.2 to 83.9 percent in infected quarters (both subclinical and clinical) assessed by comparison with yields of opposite healthy quarters. Landrey (1966) noted an estimated loss in milk yield of 10.5 percent of the total potential production of cows that were affected at least once by mastitis as indicated by California Mastitis Test (CMT) and strip cup; however, the lactational loss amounted to 25 percent when bacteria were being isolated. Forster et al. (1967) and Janzen (1970) found that CMT reactions (on total quarter milk) of trace, one , two and three, were associated with average descreases of 0.34 (9.0 percent) to 2.7 (43.4 percent) kg. per quarter per day. Comparing two opposite quarters using the CMT, the effect of a subclinical infection on reduced quarter milk yield ranged from 2.8 to 45.5 percent (Philpot, 1958; Philpot and Johns, 1967). Roberts et al. (1969) reported that the weighted average decrease in milk production associated with all CMT reactions was 14.3 percent. Daniel, Biggs and Barnum (1966) observed a significant linear relationship between CMT score and monthly milk yield with milk decreasing 22.2 kg. per month for each one unit increase in a CMT score. Appleman, Rowe and Forker (1965) found 0.41 to 3.08 kg. less milk was produced for the CMT trace, 1, 2 and 3 reactions. Natzke et al. (1965) reported estimated losses in milk production of quarters with CMT scores of 1, 2 and 3, compared to opposite negative quarters, were 0.19, 0.29 and 0.67 kg.

per quarter per milking respectively. King (1967) demonstrated the average milk yield was reduced 0.64 kg. ($P < .05$) from opposite quarters (two fore or two hind), one not infected and the other having been infected with mastitis; however, a nonsignificant difference in average yield of 0.24 kg. was found on samples taken 28 days after initial sampling. O'Donovan, Dodd and Neave (1960) and Wheelock et al. (1966) stated that milk production remained 10 percent below the expected level following prompt elimination of a mastitis infection. Gray and Schalm (1962) compared lactation yields between CMT negative and CMT positive groups and observed average loss of 6.0, 10.0, 16.0 and 24.5 percent for the CMT positive group with scores of trace, 1, 2 and 3, respectively.

Crossman et al. (1950) reported that subclinical streptococcal and hemolytic staphylococcal infections, which cause over 80 percent of all infections, were associated with gradual reductions in the proportionate milk yield or have no measureable affect. However, clinical streptococcal and hemoyltic straphylococcal infections were associated with sudden drops in milk yield of significant amounts. Plastridge (1958) cited several authors in which Strep. agalactiae caused a 10 to 14.8 percent reduction in quarter milk yield. Wheelock et al. (1966) reported that the infusion of Strep. dysgalactiae and Staph. aureus into non-infected quarters reduced milk yield 20 to 70 percent in relation to opposite non-infected quarters. Quarters which harbored Staph. aureus produced 760 kg. less milk per lactation, whereas quarters which harbored other forms of bacteria produced 500 kg. less milk per lactation (Natzke et al. (1972). Hopkirk (1972) noted an average milk loss of 395 kg. per lactation when a quarter was harboring pathogenic bacteria.

TABLE I

SUMMARY OF REPORTED LOSSES IN MILK YIELD DUE TO MASTITIS INFECTION

Researcher(s)	Year	Loss Due to Mastitis	Remarks
Gray and Schalm	1962	6.0 to 24.5%	Based on total lactation yield-comparing CMT positive group to CMT negative group
Rako et al.	1962	15.2 to 83.9%	Difference between yield of positive CMT quarters to negative CMT quarters
Appleman et al.	1965	0.41 to 3.08 kg. per cow per day	Same as above
Natzke et al.	1965	0.19 to 0.67 kg. per quarter per milking	Same as above
Daniel et al.	1966	22.23 kg. per month per unit CMT	Linear relationship between CMT score and monthly milk yield
Landrey	1966	10.5 to 25%	Decrease in total production due to infection
Forster et al.	1967	0.42 (9.0%) to 2.33 (43.4%) kg. per quarter per day	Difference between positive CMT quarter and negative CMT quarter
Philpot and Johns	1967	2.8 to 45.5% per quarter per day	Same as above
King	1967	0.21 to 1.27 kg. per 290 days	Difference between positive and negative quarter yield over 290 days
Roberts et al.	1969	14.3%	Average of all CMT reactions between CMT positive and CMT negative quarter
Janzen	1970	0.34 (9.0% to 2.66 (43.3%) kg. per quarter per day	Difference between CMT positive and CMT negative quarter

Effect on Milk Composition

The infection of quarters with pathogenic bacteria cause severe damage to secretory cells and adjacent connective tissue resulting in the alteration of milk composition, which generally lowers milk quality. Lowered milk quality leads to low returns for the dairy producer, because the regulations placed on selling milk demand a minimum percentage of certain milk components. Newbould and Neave (1965A) suggested that the entrance and multiplication of only a small number of pathogenic bacteria were required to cause the milk composition to be altered. O'Donovan et al. (1960) found that lactation yields of non-fat solids and fat were significantly depressed in milk from cows with Staph. pyogenes (Staph. aureus) infected quarters, whether these quarters showed clinical signs or not. In a review on the effects of mastitis on yield and composition, King (1967) noted that the more severely the milk secreting mechanism is injured, the more milk composition would appear like the composition of blood serum. Several authors (Shaw and Beam, 1935; McKenzie, Booker and Moore, 1958; Wheelock et al., 1966; King, 1967) have noted that compositional changes involved (1) lowered milk fat percent, (2) lowered lactose and casein percent, (3) lowered non-fat solids percent, (4) increased sodium, phosphorus and chloride contents, (5) increased percent of soluble nitrogen and (6) a decline in the natural acidity. Janzen (1970) cited losses of 0.1 to 0.45 percent fat, 0.1 to 0.57 percent non-fat solids, 0.1 t0 0.77 percent lactose and up to 1.07 percent total solids in milk from infected cows. Philpot and Johns (1967) found that fat content in milk decreased 3.4, 6.0, 10.3 and 13.7 percent in quarters with CMT reactions of trace, 1, 2 and 3, respectively. Non-fat solids decreased 0.7, 2.8, 6.4 and 11.3 percent in quarters with CMT reactions of trace, 1, 2 and 3, respectively. Miller (1973) noted clinical infections to lower milk fat 10 to 15 percent, non-fat solids 3 to 11 percent, and lactose 2 to 41 percent. King (1967) reported a non-significant reduction in milk fat percent in heifers due to infected quarters, but a significant decrease of 1.03 percent in non-fat solids percent. Milk from subclinically infected heifers had a 10 percent reduction in total lactose content in the first or second lactation; however, milk from clinically infected heifers was 20 percent lower in total lactose content in the first or second lactation (Miller, 1973). *Strep. agalactiae*, *Strep. dysgalactiae*, *Strep. uberis* and *Staph. aureus* are the pathogens which have been reported to be associated with significant changes in milk composition (King, 1972).

Cost of Drugs and Therapy

Costs relating to mastitis prevalence appear to be enormous; however, participation in some form of mastitis control program would reduce costs substantially. Janzen (1970) cited papers wherein yearly costs per cow attributed to mastitis infection prior to a mastitis control program were (1) losses in milk production, $124.08, (2) discarded milk, $4.04, (3) drug costs, $1.80, (4) veterinary fees, $0.60 and (5) extra labor, $0.60. After participating two years in a control program the losses per cow per year were (1) losses in milk production, $23.70, (2) discarded milk, $0.69, (3) drug costs, $0.41 and (4) extra labor, $0.11. Marshall (1961) noted costs of $5.47 per cow for a mastitis control program which included drugs, therapy and milk loss during a 40 week period. Fincher (1963) estimated that costs in eliminating *Strep. agalactiae* were (1) $0.25 per cow for laboratory fees, (2) $10 per hour for the cooperating veterinarian for his visit to the farm and (3) $1.50 per treatment per quarter. Appleman et al. (1965) found milk loss due to mastitis to cost 2.2, 11.3, 23.7 and 32.6 cents per cow per day with CMT reactions of trace, 1, 2, and 3, respectively. A subclinical infection in typical North Louisiana herds cost from $1.82 to $31.71 per cow a year without considering costs of discarded milk (Philpot and Johns, 1967). Natzke et al. (1972) found a mastitis control program which included a 4 percent chlorine teat dip and a dry cow antibiotic preparation (i.e., 1 million units penicillin and 1 gram dihydrostreptomycin) to cost $0.60 per 6 liters of teat dip and $4.00 per 4 antibiotic treatments.

Effect on Culling and Replacement Heifers

Culling a cow with a chronic case of mastitis is often the only successful means of eliminating an infection. Replacing a culled cow causes a substantial loss to the dairy producer because of reduced milk yield of the heifer and the difference between the market value of a new cow versus the carcass value of the culled cow. Morris (1971) stated that the benefits obtained from an improved control program which would allow farmers to modify their replacement policy would reach a gross return of $1,050 per 100 cows when mastitis prevalence was reduced from 30 to 10 percent of quarters.

Infection Process

Bovine mastitis is an acute, subacute or chronic transmissible infectious disease caused by Staphylococcus, Streptococcus, Pseudomonas, coliform, klebsiella, and Corynebacterium bacteria, and which may be characterized by inflammation, swelling, redness and heating in quarters followed with an exudate consisting of dead and clumped leukocytes.

Infectious Agents

Staph. aureus, Strep. agalactiae, Strep. dysgalactiae, Strep. uberis, Corynebacterium pyogenes, Pseudomonas aerugenosa, Klebsiella sp. and E. coli are the pathogens most frequently found associated with a mastitis infection (Dodd, Neave and Kingwill, 1964; Smith et al., 1966; Smith et al., 1967; Dodd et al., 1969; Roberts et al., 1969; Hopkirk, 1972). Fifty percent of all dairy cows are believed to be harboring these pathogens, with 75 percent of the infections being the subclinical type (Roberts et al., 1969). Smith et al. (1967) suggested that fifty percent of all the infections present at the end of a lactation and start of a subsequent lactation are predominantly Staph. aureus. In one study, Neave et al. (1968) reported that the majority of new dry period infections were caused by Strep. dysgalactiae. Field (1968) noted Strep. agalactiae to have caused 90 percent of the infections in 318 New York dairy herds reporting high modified whiteside reactions. Roberts et al. (1969) reported that 97 percent of the mastitis infections over an 18 month period in 27 dairy herds to be caused by gram positive bacteria, whereas gram negative bacteria were responsible for only 1 percent. Smith (1969) reported that in viewing milk culture records on 20,000 dairy cows from the state of Washington, 30.6 percent were infected with Strep. agalactiae and 26.1 percent were infected with Staph. aureus.

A number of factors have been cited as predisposing factors in the incidence of mastitis. Including in these are (1) enlarged and pendulous udders (Roberts et al., 1969; King, 1972), (2) contaminated teat creams, syringes, and teat syphons (Brander, 1973), (3) infected sores, lesions, abscesses and blemishes (Smith et al., 1966; Jackson, 1970; Janzen, 1970), (4) chilled and chapped teats (Miller and West, 1956), (5) excessive degree of vacuum and pulsation (Miller and West, 1956; Pier, Schalm and Hage, 1956; Jasper, 1969; Jackson, 1970), (6) undermilking overmilking (Dodd et al., 1964; Neave et al., 1968; Hopkirk, 1972; King, 1972; Pearson et al., 1972), (7) machine and handstripping (Miller and West, 1956), (8) increased intramammary pressure (Hopkirk, 1972), (9) physiological stress (Jasper, 1969; Hopkirk, 1972) and (10) advancing lactation age (Oliver et al., 1956; Gray and Schalm, 1962; King, 1972; Hopkirk, 1972; Pearson et al., 1972). A few factors have been cited as direct causes connected to increased mastitis infection. Including in these are (1) bacterial colonization of the teat duct (Jasper, 1969; Roberts et al., 1969), (2) a greater width of the teat canal rather than length (Schultze and Smith, 1970; Appleman, 1973), (3) unusually patent streak canals (Dodd and Neave, 1951; Newbould and Neave, 1965; Jasper, 1969; Hopkirk, 1972; Thomas et al., 1972), (4) injury (Miller and West, 1956; Pearson et al., 1972; Brander, 1973), (5) incomplete milking (Schmidt, Guthrie and Guest, 1964; Roberts et al., 1969) and (6) high milk yield at end of lactation (Roberts et al., 1969; Janzen, 1970; Pearson et al., 1972). Work conducted by Thomas et al. (1972) on rate of new infections suggested intramammary pressure, leakage of milk, and bacterial inhibitors to have no effect on the rate of new infections.

Cycle of Infection

Entrance of pathogenic and non-pathogenic bacteria into the bovine mammary gland occurs through the streak canal. Roberts et al. (1969)

suggested that the teat canal may be infected with bacteria for a period of time before they actually multiply and enter the teat cistern. Once bacteria are present in the teat canal, a suction developed during milking either by hand or machine results in the pathogens being carried into the teat cistern (Pier et al., 1956). Roberts et al. (1969) noted that the presence of milk in the teat canal constitutes an important vehicle in the passage of bacteria into the udder, and residual milk in the teat cistern encourages bacterial development. Newbould and Neave (1965) infused quarters with Staph. aureus and recovered them in the foremilk on the first post-infusion miling. They concluded that milk in normal uninfected glands was unable to prevent the multiplication of Staph. aureus. Cousins et al. (1973) reported that bacteria implanted in the teat during milking in late lactation were less likely to be washed out than bacteria implanted earlier in lactation. Paape (1973) noted that the first detection of quarters being infected (i.e., appearance of dead and clumped leukocytes on strip cups) was approximately 24 hours after bacterial invasion. Edwards and Smith (1970) and Natzke (1971) suggested that Staphylococci become residents of udders early in the course of infection by localizing and multiplying within pockets of fibrous tissue present in the gland. Five possible outcomes for infected quarters noted by Dodd et al. (1964) and Roberts et al. (1969) are (1) the subclinical infection would be eliminated spontaneously, (2) the subclinical infection would progress to a clinical infection, (3) the subclinical or clinical infection would be eliminated by drug therapy, (4) the clinically infected quarter may become blind, or (5) the animal may die due to the infection.

Pathogenicity

Jasper (1969) reported that bacteria need to colonize in the teat duct before an udder infection can develop. Gram-negative bacteria are found primarily in the feces and damp areas, whereas gram-positive bacteria are primarily of animal origin, and can be found on the skin, udder, leg and anal region of the cow, causing the teat ducts to be constantly exposed to pathogenic bacteria for colonization (Miller and Lewis, 1956; Jasper, 1969; Roberts et al., 1969; Jackson, 1970; Eberhart and Buckalew, 1972; Hopkirk, 1972; Brander, 1973). By swabbing teat sphincters prior to milking, Brander (1973) found that potential pathogens were regularly present on the teat sphincter. Schultze and Smith (1970) reported that Staph. aureus and Staph. epidermidis were resident populations on teat apexes. On the contrary, Orr and Taylor (1968) reported that coagulase-negative Staphylococci from infected quarters were able to colonize teat skin, whereas coagulase-positive Staphylococci were unable to colonize teat skin. Smith et al. (1966) cited Oliver, Neave and Sharpe (1962) as stating that high rates of new dry period infections were caused by pathogenic bacteria colonizing teat ducts and teat skin in late lactation. Jasper (1969) and Philpot (1969) reported that Staphylococci and coliform produced an endotoxin which caused increased cell and tissue destruction. Bovine polymorphonuclear leukocytes were found unable to stop cell and tissue destruction immediately following invasion by small numbers of bacteria, but after multiplication of bacteria producing higher titers of endotoxin, cell and tissue destruction was partially stopped (Reiter, 1969; Paape, 1973). Crossman et al. (1950) suggested that a subclinical infection with less common types of Staphylococci or Streptococci may not cause as much extensive damage as typical strains of these organisms, because the inflammatory process would destroy the original pathogens entering the gland.

Dipping Teats With Bacterial Suspensions or Infusing Bacteria Into Teats

Newbould and Neave (1965A), Jasper (1969), Schultze and Smith (1970) and Reiter (1969) suggested that with the infusion of a small number of Staphylococci into the teat canal, quarters develop a case of mastitis with rapid multiplication of the pathogens producing large quantities of endotoxin. Newbould and Neave (1965A) deposited 10 to 600 coagulase positive Staphylococci into the outer 4 mm. of the teat canal. An eight percent infection rate occurred when the infused quarters were milked daily, whereas there was a 23 percent infection rate when the first post-inoculum milking was omitted. Schultze and Smith (1970) discovered that a greater proportion of infections resulted when Staph. aureus was deposited into the teat canal at a depth of 5 mm. than when the bacteria was deposited at 3 mm. Newbould and Neave (1965A) noted that infusing atypical strains of Staphylococci (i.e., coagulase-negative) at 8.84 to 15.59 colony forming units (CFU) per quarter caused 2 of 10 quarters to develop an infection; further, after infusing two typical strains of Staphylococci (i.e., two coagulase-positive) at 5.0 to 52.5 and 23.75 ± 5.70 CFU per quarter, respectively, 23 of 46 quarters were infected with coagulase-positive strain F, while 3 of 3 quarters were infected with coagulase-positive strain d. Neave et al. (1968) contaminated milked and unmilked quarters of six cows with a mixed suspension of Streptococci and Staphylococci and found only the unmilked quarters infected.

Periods of High Exposure

The time of highest exposure to potential pathogens was during the early dry period and following calving (Smith et al., 1966, 1967; Munch-Petersen, 1968; Roberts et al., 1969; Janzen, 1970; Thomas et al., 1972). Orr and Taylor (1968), Janzen (1970) and King (1972) reported that a higher incidence of infections was associated with the warmer, dry months. However, Schultze and Smith (1972) found that coliform infections were more prevalent during the wetter months, October to December. Orr and Tyalor (1968) observed a seasonal trend in bacterial counts on the teat surface, with 76.6 percent of the Staph. aureus isolates being detected May to October. Neave, Dodd and Henriques (1950), Dodd et al. (1964), Neave et al. (1968), Jasper (1969), and Roberts et al. (1969) found the greatest incidence of mastitis during the first three weeks of the dry period, with 7.87 percent infections per week in the first three weeks and 0.2 percent infections per week for the remaining eleven weeks. Dodd et al. (1964) and Roberts et al. (1969) reported that in the latter stages of the dry period the udder skin of heifers and non-lactating cows was usually free of pathogenic bacteria. Munch-Petersen (1968) found that 81.5, 84.5 and 93.3 percent of the first calf heifers in three separate trials were free from infections immediately following calving.

Sanitation

Hygiene Measures

Hygiene systems minimize the transfer of pathogenic and non-pathogenic bacteria from diseased to healthy quarters during milking (Wilson, 1955; Newbould and Barnum, 1960; Johns, 1966; McDonald, 1969; Neave et al., 1969; Edwards and Smith, 1970). Wilson (1955), Newbould and Barnum (1960), Dodd et al. (1964), Newbould (1965), Neave et al. (1969) and Roberts et al. (1969) reported that pathogens were found on (1) milkers hands, (2) udder wash cloths, (3) milking machine equipment and (4) teats and udder skin surfaces. Johns (1966) recommended that four steps were necessary in reducing the transfer of these organisms: disinfecting milkers hands, washing teats and udders with approved disinfectants, sanitizing milking equipment between cows, and dipping teats of cows after each milking with approved disinfectant solutions. Wilson (1955) suggested that the disinfectant solutions be (1) non-toxic, (2) non-irritant, (3) odorless, (4) equally efficient at killing gram-positive and gram-negative organisms, and (5) efficient in killing a high percentage of organisms rapidly. Several researchers (Newbould, 1965; Johns, 1966; Neave et al., 1969; McDonald, 1969; Roberts et al., 1969; Kingwill et al., 1970) recommended the use of (1) separate single service paper towels for washing and drying individual udders and teats, (2) machine stripping rather than hand stripping, (3) sanitizing milking equipment between milkings of each cow, (4) disinfecting milkers hands, and (5) dipping teats of cows immediately after milking with an approved disinfectant solution.

Dipping teats immediately after milking cows (either by 1 percent iodophor solution or 0.5 percent P.V.P.-Hibitane solution) and pasteurizing teat cups (immersing teat cups for 15 seconds in water at 165^{o} to 170^{o}F) reduced the number of Micrococci and hemolytic Staphylococci on the rubber inflators (Newbould and Barnum, 1960). Teat dipping alone controlled total numbers of Micrococci, whereas total numbers of hemolytic

Staphylococci increased with discontinued pasteurization of teat cups. Neave et al. (1969) noted that a comprehensive hygiene sytem has two objectives: prevention of intramammary infections during milking, and prevention of infection between one milking and the next. They found no significant difference in number of infections developing when comparing full hygiene (i.e., single service paper towels or boiled cloths for washing each udder, wearing rubber gloves by milkers, pasteurizing teat cut clusters before milking each cow, and post-milking disinfection of each teat) to partial hygiene (same as above mentioned excluding pasteurization of teat cup clusters). Furthermore, improvement due to pasteurization of teat cup clusters was small and apparently unnecessary for a significant reduction in new infections. Both the full and partial hygiene system were significantly different from no hygiene in the number of infesctions developed. Kingwill et al. (1970) found that a partial hygiene system (i.e., wearing rubber gloves, disinfecting gloved hands, washing udders with a hypochlorite solution, and using single service paper towels) compared to post-milking teat dipping (i.e., 4 percent sodium hypochlorite) was no different in the number of infections developing. Wilson (1955) found that hypochlorite disinfectants were inactivated in the presence of greater than 2 percent organic matter. He changed to a Hibitane disinfectant, which was efficient in reducing the colonies of Strep. agalactiae on the rubber inflations. Quaternary ammonium disinfectants were tried, because these disinfectants were not inactivated by organic matter; however, the quaternary ammonium disinfectants were efficient only against gram-positive organisms. Newbould (1965) reported that water disinfectants caused the colonies of Micrococci on rubber inflators to increase ($P < .02$), whereas Iosan (100 ppm), tincture of iodine (1 or 2.5 percent), and ethyl alcohol (70 percent) reduced significantly the colonies of Micrococci.

Post Milking Teat Dip

The practice of dipping teats of each cow immediately after milking is one sanitary practice that reduces or eliminates organisms from teat skins after milking (Newbould and Barnum, 1960; Tripathy, Fincher and Bruner, 1963; Newbould, 1965; Johns, 1966; McDonald, 1969; Neave et al., 1969; Roberts et al., 1969; Kingwill et al., 1970; Wesen and Schultz, 1970). Teat dipping after each milking prevented teat canal infections by destroying pathogens contaminating teat apexes (Neave et al., 1969). In evaluating a group of various disinfectants as teat dipping agents after each milking, Newbould and Barnum (1958) found that the number of Micrococci recovered from the teat cup liners were reduced significantly by Iosan (100 ppm), sodium hypochlorite (1000 ppm), tincture of iodine (1 and 2.5 percent) and ethanol (70 percent), whereas a water dip increased significantly the number of Micrococci. Hibitane was variable, decreasing the number of Micrococci at low concentrations (100 and 200 ppm), but increasing the number of Micrococci at high concentrations (400 and 800 ppm). By exposing teats of 27 cows with Strep. agalactiae and Strep. dysgalactiae, Neave et al. (1969) found that dipping teats after each milking with a 0.5 percent chlorhexidine disinfectant produced a seven-fold decrease in new streptococcal infections. Oliver, Neave and Sharpe (1962) made a within-cow comparison on udder infections in dry cows whose teats were deliberately contaminated with a mixed culture of Strep. uberis and Staph. aureus. They found that teat dipping after the last milking with a 2 percent chlorhexidine disinfectant reduced significantly the number of new dry period infections, 6 of 37 (16.2 percent) of the dipped quarters compared to 13 of 37 (35.1 percent) of the undipped quarters. The 2 percent chlorhexidine teat dip reduced the number of new infections caused by Staph. aureus, but the teat dip had no effect on Strep. uberis. Schultze and Smith (1970) noted a 96.9 percent reduction of the resident Staphylococci microflora by use of a 0.2 percent chlorhexidine teat dip to sanitize half udders of twelve cows. Chlorhexidine was retained on roughened teat skin for at least six hours after dipping, whereas smooth teat skin was ineffective at retaining chlorhexidine. Bovadine (10,000 ppm available iodine) was found to reduce new infections by 53.2 percent (Wesen and Schultz, 1970). It was effective in preventing new infections with Streptococci and Staph. aureus, but did not appear to prevent new infections with gram-negative rods. Schultze and Smith (1972) found dipping teats with a 1 percent iodophor or 0.2 percent chlorhexidine teat dip achieved essentially the same low rate of new infections. Considering only gram positive cocci, the two teat dip preparations were equally efficient in reducing new infections, 81 percent compared to 79 percent for chlorhexidine and iodophor, respectively, but neither seemed to protect against infection by coliform or Pseudomonas species. Natzke and Bray (1973) found that a dip percent chlorine teat dip and a 1 percent iodine teat dip did not differ significantly; both reduced new infections by 28 percent for one year. Each teat dip group had 0.62 percent new infections per year. In evaluating a group of different disinfectants (Roccal[a] at 200 ppm.

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[a]Commercial preparation consisting of 10% aqueous benzalkonium chloride.

Pennsan[b] at 200 ppm, Iosan[c] at 100 ppm, Nolvasan[d] at 600 ppm, and B. K. chlorine-bearing powder[e] at 200 ppm) as teat dipping agents after each milking, Tripathy et al. (1963) tested their bactericidal action by collecting a teat swab prior to dipping and immediately after dipping. They found that Nolvasan at 600 ppm to be the best of the five disinfectants in reducing the mean percentage of Micrococci and nonagalactiae streptococci on the teat surface. It reduced the number of Micrococci by 68 percent, whereas all other disinfectants reduced the number of Micrococci no more than 50 percent. Pennsan at 200 ppm was found the least effective, reducing Micrococci by only 29.3 percent. Nolvasan at 600 ppm and B. K. chlorine bearing powder at 200 ppm reduced the number of nonagalactiae streptococci by 68.3 and 62.5 percent, respectively, whereas Roccal and Pennsan at 200 ppm reduced nonagalactiae streptococci by 55 and 51.5 percent. Iosan at 100 ppm was found the least effective, reducing nonagalactiae streptococci only 40 percent. On the contrary, Edwards and Smith (1970) found that the practice of outinely dipping teats chlorhexidine and iodophor after each milking had a non-significant effect on the incidence of new staphylococcal infections.

Gerring, Hall and Sandoe (1968) found that new infections caused by Staph. aureus were reduced 81 to 97 percent by use of a 1.0 percent chlorhexidine teat dip. Orr and Taylor (1968) reported that staphylococcal counts on the teat skin were affected by dipping teats with a

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[b]Combination of wetting agent and an acid.

[c]Iodine preparation, i.e., 1.75 percent available iodine.

[d]Synthetic chemical, i.e., 2 percent hexamethylenebis diacetate.

[e]50 percent calcium hypochlorite.

commercial iodophor teat dip.

Post Lactation Teat Dip

Oliver, Dodd and Neave (1956) noted that a high incidence of early dry period infections was caused by pathogens remaining on the teat skin after the last milking of the lactation. New infections in the dry period were reduced significantly by dipping teats in a 5 percent tincture of iodine solution for 20 seconds after the last milking, and again twenty-four hours later. The proportion of cows becoming infected in the experiemental group was 48.7 percent compared to 72.5 percent in the control group. New quarter infection rate in the teat dipped group was 23.2 percent, compared to 31.2 percent in the control group. The tincture of iodine teat dip reduced the number of new infections caused by Staph. aureus, whereas the teat dip had no effect on Strep. uberis. Brown et al. (1965) noted that disinfecting teats after the last milking and again 24 hours later with iodine or chlorhexidine prevented staphylococcal infections during the dry period, but these treatments were not effective in preventing udder infections by Strep. uberis. Teat dipping once a day for seven days after drying off with Bovadine (10,000 ppm available iodine) significantly reduced the number of new dry period infections (Thoreson, 1973). New infections in the teat dipped group were 4.76 percent, compared to 33.3 percent in the undipped group. On the contrary, Wesen and Schultz (1970) reported that the incidence of new infections during the dry period was not reduced by teat dipping the first few days of the dry period with a Bovadine (10,000 ppm available iodine) teat dip. They found that there were 19 new infections on the dipped side and 18 new infections on the undipped side of 81 cows. They

TABLE II

SUMMARY OF REPORTED RESULTS ON TEAT DISINFECTION

Researcher	No. of Cows or Quarters	Control Group	Criteria Measured	Teat Disinfection	Effect of Treatment	Remarks
I. <u>Post Milking Teat Dip</u>						
Newbould & Barnum (1958)	3 cows	Yes	Difference in number of Micrococci recovered on the teat skin between dipped and undipped teats	water only	+5600	within cow comparison
				Iosan		
				50 ppm	-4000	
				100 ppm	-8200	
				Hibitane		
				100 ppm	-8000	
				200 ppm	-4100	
				400 ppm	+2000	
				800 ppm	+2000	
				Na Hypochloriet		
				1000 ppm	-6800	
				Tincture of Iodine		
				1.0%	-8400	
				2.5%	-11400	
				Ethanol 70%	-12000	
Schultze & Smith (1970)	12 cows	Yes	% reduction in Staphyl-	0.2% chlorhexidine	96.9%	Daily contamination of milking machines
Wesen & Schultz (1970)	124 cows	Yes	% reduction in new infections	Iodine Teat Dip (10,000 ppm available iodine)	53.2%	Rt. side teats dipped and left side teats not dipped
			% reduction in new infections			
			<u>Staph. aureus</u>		25%	
			<u>Strep. agalactiae</u>		67%	
			nonagalactiae Streptococci		65%	
Schultze & Smith (1973)	62 cows	Yes	% reduction in teat apex microflora	1% iodophor	79%	Only gram positive cocci considered
				0.2% chlorhexidine	81%	
Natzke & Bray (1973)	189 cows	Yes	% reduction in new infections for a period of one year	4% chlorine	28%	
				1% iodine	28%	

TABLE II (Continued)

Reacher	No. of Cows or Quarters	Control Group	Criteria Measured	Teat Disinfection	Effect of Treatment	Remakrs
					Mic. Strep.	
Tripathy et al. (1963)	4 cows	Yes	% reduction of Micrococci and Streptococci on the teat skin before and after teat disinfection	Roccal 200 ppm Iosan 100 ppm Nolvasan 600 ppm Pennsan 200 ppm B.K. chlorine 200 ppm bearing powder	47.7 55.0 36.6 40.3 68.1 68.3 29.3 62.5 48.5 51.5	Within-cow comparison
Oliver et al. (1962)	37 cows	Yes	% reduction in udder infections	2% chlorhexidine	53.8%	Within-cow comparison
Gerring et al. (1968)	6 cows	No	Mean % reduction of No. _Staph._ _aureus_ recovered from teats following treatment	1.0% chlorhexidine	81 to 97%	Range
II. Post Lactation Teat Dip						
Oliver et al. (1956)	79 cows	Yes	% new infections occuring between dipped and undipped cows	5% tincture of iodine	48.7 vs. 72.5%	
	279 cows	Yes	% new infections occurring between dipped and undipped quarters	5% tincture of	23.2 vs 31.2%	
Wesen & Schultz (1970)	81 cows	Yes	% new infections between dipped and undipped cows	1% Bovadine	36.0 vs 31%	
Thoreson (1973)	42 cows	Yes	% new infections between dipped and undipped cows	1% Bovadine	4.76 vs 33.3%	
Ward & Schultz (1973)	402 cows	Yes	% new infections between dipped and undipped quarters	1% Iodophor	5.6 vs 9.5%	Teats on one side of all cows were dipped

noted that the percentage of infections caused by each pathogen was approximately the same in the two groups, i.e., Staph. aureus 24 percent, Strep. agalactiae 24 percent, nonagalactiae Streptococci 49 percent, and gram negative rods 3 percent. Ward and Schultz (1973) found that teat dipping once a day for seven days after drying-off with a 1% iodophor reduced the number of new dry period infections, i.e., 5.6 percent in the dipped group compared to 9.5 percent in the undipped group.

Dry Cow Therapy

Dry cow treatment reduce infections significantly more than lactational therapy due to the prevention of new infections (Kingwill et al., 1970; Brander, 1972). Some advantages of dry cow treatment (Dodd et al., 1964; Roberts et al., 1969; Kingwill et al., 1970) include (1) shorter duration of infection, (2) prevention of new infections by Corynebacterium pyogenes, (3) use of preparations specially developed for the dry period to be most effective against staphylococcal infections, (4) no contamination of saleable milk, (5) regeneration of damaged tissue, and (6) reduction in level of infection at the time of highest milk production. For dry cow treatment to be most effective, it must possess two properties: the drug should be able to eliminate all forms of infection, including those infections caused by penicillinase producing microorganisms, and it should be able to persist in the dry udder long enough to prevent development of new infections (Smith et al., 1966, 1967).

Elimination

Smith et al. (1966) studied the effectiveness of two cloxacillin preparations (0.2 gram sodium cloxacillin and 1.0 gram benzathine cloxacillin) for eliminating infections that were present at drying off. Teats of treated cows were dipped in a hypochlorite solution (5 percent available chlorine) but control cows were not. Fifty percent of all the cows were infected at drying off; 61 percent in the control group, 23 percent of the cows treated with 0.2 gram sodium cloxacillin plus teat dipping, and only 15 percent of the cows treated with 1.0 gram benzathine cloxacillin plus teat dipping were infected at calving. The decrease in total infections for the treated cows was caused by the reduction of staphylococcal infections. Ninty-eight percent of the streptococcal infections which were present at drying off were eliminated by the cloxacillin treatments. Kingwill et al. (1967) noted that 0.5 gram benzathine cloxacillin and 1.0 gram benzathine cloxacillin were equally effective in eliminating infections that were present at drying off. The 0.5 gram benzathine cloxacillin treatment eliminated 78 percent of the Staph. aureus infections and 95 percent of the streptococcal infections, whereas the 1.0 gram benzathine cloxacillin treatment eliminated 74 percent of the Staph. aureus infections and 97 percent of the streptococcal infections. New infections for the two cloxacillin treatment groups were 3.6 percent of the quarters.

Smith et al. (1967) conducted a field trial involving 888 cows in 35 herds to test the effectiveness of two forms of cloxacillin as treatments in eliminating infections that were present at drying off. The treatments were 1.0 gram benzathine cloxacillin infused into each quarter, 0.2 gram sodium cloxacillin, and controls. All infused quarters were teat dipped at drying off with a hypochlorite disinfectant (5 percent available chlorine). Sixty-two percent of the control cows were infected at calving. The 0.2 gram sodium cloxacillin treatment reduced the number of infections at calving to 26.0 percent, and the 1.0 gram benzathine cloxacillin treatment reduced the number of infections to 15.6 percent. The proportion of cows infected with Staph. aureus in the control group increased from 28.4 to 38.3 percent at calving, whereas it declined from 31.9 to 13.6 percent for the 0.2 gram sodium cloxacillin treatment and from 28.7 to 5.9 percent for the 1.0 gram benzathine cloxacillin treatment. The number of streptococcal infections increased from 30.0 to 33.7 percent in the control group, whereas it decreased from 28.4 to 6.7 percent for 0.2 gram sodium cloxacillin treatment and from 31.2 to 8.5 percent for the 1.0 gram benzathine cloxacillin treatment. Brookbanks (1968) conducted a small scale trial involving 126 cows in 2 herds to test the effectiveness of 0.5 gram benzathine cloxacillin compared with no treatment in eliminating staphylococcal and streptococcal infections present at drying off. In herd I, 0.5 gram benzathine cloxacillin treatment eliminated 75 percent of the staphylococcal and 100 percent of the streptococcal infections from the quarters at calving, whereas 13 percent of the staphylococcal and 70 percent of the Streptococcal infections were eliminated from the quarters with no treatment. In herd 2, 0.5 gram benzathine cloxacillin treatment eliminated only 48 percent of the staphylococcal and 100 percent of the streptococcal infections from the quarters prior to calving, whereas 21 percent of the staphylococcal and 57 percent of the streptococcal infections were eliminated with no treatment. Pearson and Wright (1969) tested three different antibiotic preparations (0.2 gram sodium cloxacillin, 0.3 gram procaine penicillin G, and 0.25 gram novobiocin plus 0.3 gram procaine penicillin G) for eliminating staphylococcal and streptococcal infections from quarters that were infected at drying off. Treatment with 0.3 gram procaine penicillin G eliminated 100 percent of the streptococcal infections from the quarters, and 0.2 gram sodium cloxacillin eliminated 75 percent of the Staph. aureus infections. The control group developed 6.7 percent new streptococcal infections and 4.8 percent new staphylococcal infections prior to calving. In a second trial, Pearson and Wright (1969) compared 145 treated quarters (0.5 gram benzathine cloxacillin) on the right side with 140 nontreated quarters on the left side of seventy cows. All quarters were teat dipped with an Iodophor disinfectant. Cloxacillin eliminated 100 percent of the streptococcal and 56 percent of the staphylococcal infections from the quarters by calving, compared to from spontaneous recovery from 44 percent of the streptococcal and 39 percent of the staphylococcal infections in control quarters. Langley et al. (1971) conducted a trial involving 363 quarters to test the effectiveness of 0.5 grams benzathine cloxacillin in eliminating Staph. aureus infections that were present at drying off. All infused quarters were teat dipped in an Iosan solution (15,000 ppm available iodine). The cloxacillin plus teat dipping eliminated 78.9 percent of the Staph. aureus infections by calving, whereas 16.7 percent of the Staph. aureus infections were eliminated from the quarters with no treatment. Rosenzuaig and Mayer (1970) found a 61.4 percent clearance of staphylococcal infections during the dry period as a result of infusing 0.5 gram benzathine cloxacillin per quarter and teat dipping with a 5,000 ppm Iodophor, compared to 13.1 percent clearance for controls. Eberhart and Buckalew (1972) conducted a trial involving 200 cows to test theeffectiveness of 200,000 units procaine penicillin G and 0.1 gram dihydrostreptomycin in eliminating infections present at drying off. All infused quarters were teat dipped in an Iodophor solution (10,000 ppm available iodine). The penicillin G and dihydrostreptomycin eliminated 100 percent of the Strep. agalactiae, 96 percent of the Staph. aureus, and 80 percent of the nonagalactiae Streptococci infections from quarters by calving, compared to 41, 24, and 43 percent elimination, respectively, for controls.

Brookbanks (1968) used two treatments (0.5 gram benzathine cloxacillin, 0.3 gram penicillin G plus 0.25 gram novobiocin) and no control to study the effectiveness of drug therapy in eliminating Staph. aureus and streptococcal infections that were present at drying off. The 0.5 gram benzathine cloxacillin treatment eliminated 69 percent of the Staph. aureus and 91.6 percent of the streptococcal infections from the quarters, whereas 0.3 gram penicillin G and 0.25 gram novobiocin treatment eliminated 60 percent of the Staph. aureus and 100 percent of the streptococcal infections from quarters at calving. Loosmore et al. (1968) conducted a field trial involving 578 cows to test the effectiveness of three antibiotic preparations in eliminating infections during the dry period. The treatments consisted of (1) 0.5 gram benzathine cloxacillin (slow release base), (2) 0.25 gram sodium novobiocin and 300,000 units penicillin (slow release base), and (3) 0.25 gram spiramycin (quick release base). No control group was used to compare treatment effects. All infused quarters were teat dipped at drying off with an Iodophor solution (5,000 ppm available iodine). The 0.5 gram benzathine cloxacillin plus teat dipping treatment eliminated 62 percent, the 0.25 gram soium novobiocin and 300,000 units penicillin treatment eliminated 64.1 percent, whereas 0.5 gram spiramycin eliminated only 40.2 percent of the staphylococcal infections from quarters. All three antibiotic treatments eliminated 100 percent of the streptococcal infections from the quarters. The 0.5 gram benzathine cloxacillin, 0.25 gram novobiocin and 300,000 units penicillin, and 0.5 gram spiramycin treatments eliminated 51.5, 35.8, and 41.8 percent, respectively, of the Staph. aureus infections from cows during the dry period.

Pearson and Wright (1969) studied the effectiveness of two antibiotic preparations (0.2 gram sodium cloxacillin, and 0.3 gram procaine penicillin G) compared to no treatment in eliminating infections that were present at drying off. The infusions were done during the dry phase. The 0.2 gram sodium cloxacillin treatment eliminated 60 percent of the staphylococcal infections, whereas the 0.3 gram procaine penicillin treatment eliminated 38 percent of the staphylococcal infections from quarters during the dry period. The control group with no treatment had 16 percent of the staphylococcal infections eliminated from the quarters. Furthermore, Pearson and Wright (1969) found that 0.3 gram procaine penicillin G treatment eliminated 92 percent of the streptococcal infections, whereas 65 percent of the streptococcal infections were eliminated from the quarters with no treatment. Dodd et al. (1969A) noted that 0.2 gram sodium cloxacillin treatment eliminated from 66 infected quarters, 83 percent of the hemolytic staphylococcal infections, 76 percent of the streptococcal infections, and 100 percent of the mixed staphylococcal and streptococcal infections from quarters during the dry period.

Langley et al. (1971) conducted a trial involving 630 cows in 21 herds to test the effectiveness of three antibiotic preparations with no control in eliminating Staph. aureus infections that were present at drying off. They found that the 0.5 gram benzathine cloxacillin treatment eliminated 73 percent of the *Staph. aureus* infections, 300,000 units penicillin and 0.25 gram sodium novobiocin treatment eliminated 78 percent of the *Staph. aureus* infections, and the 300,000 units procaine benzylpenicillin and 250,000 units dihydrostreptomycin treatment eliminated 62 percent of the *Staph. aureus* infections from quarters. They noted that 0.5 gram benzathine cloxacillin treatment, 300,000 units penicillin and 0.25 gram sodium novobiocin treatment, and 300,000 units procaine benzylpenicillin and 250,000 units dihydrostreptomycin reduced the number of staphylococcal infections in quarters during the dry period to 62, 70 and 46 percent, respectively.

Prevention

Oliver et al. (1962) conducted a within-cow comparison on controlling udder infections in dry cows by deliberatly contaminating all teats with a mixed culture of *Staph. aureus* and *Strep uberis*. The right front quarter of all cows were infused with 200,000 units procaine penicillin G and 200,000 units of dihydrostreptomycin, while the right rear quarters of all cows were infused with 100,000 units procaine penicillin G and 100,000 units of dihydrostreptomycin. Two teats (RF and LF) were then immersed in a concentrated solution of chlorhexidine (2 percent) for 20 seconds. The left rear quarter of all cows were left as the untreated control (no antibiotic treatment or teat disinfection). The antibiotic treatment without teat dipping reduced significantly the number of new infections, (no new infections in quarters infused only, compared to 35.1 percent in the untreated quarters). Furthermore, the dry cow treatment significantly reduced the number of new infections, (2.7 percent new infections in quarters infused and teat dipped compared to 16.2

percent in quarters teat dipped only. The amount of antibiotic infused did not have a significant influence on the number of new dry period infections. Rosenzuaig and Mayer (1970) compared the proportion of new staphylococcal infections after 0.5 gram benzathine cloxacillin and no dry cow treatment. All infused quarters were teat dipped with an Iodophor solution (5,000 ppm available iodine), whereas the teats on the control cows were not teat dipped. The cloxacillin plus teat dipping treatment was effective in preventing new staphylococcal infections, whereas new infections developed in cow with no treatment. The proportion of cows with new staphylococcal infections was 4.7 percent in the treated group, compared to 22.3 percent in the control group. Eberhart and Buckalew (1972) compared an antibiotic preparation plus teat dipping treatment with no treatment in preventing new infections in quarters during the dry period. The antibiotic treatment consisted of 200,000 units procaine penicillin G and 1.0 gram dihydrostreptomycin infused into each quarter of alternate cows during the first week and again one week later. All infused quarters were teat dipped with an Iodophor solution (10,000 ppm available iodine), whereas the untreated quarters were not teat dipped. They found that the new quarter infections were 5.1 percent in the treated quarters, compared to 11.6 percent in the untreated quarters.

Pearson and Wright (1969) used one treatment (0.3 gram procaine penicillin G) and a control to study the effectiveness of dry cow therapy in preventing infections during the dry period. Teats were not disinfected in either group at drying off. They found no significant difference in new infections between procaine penicillin treated and untreated quarters. New infections in the treated quarters were 14 percent compared to 16 percent in the untreated quarters. There were 10.96

percent new staphylococcal infections, 1.37 percent new streptococcal infections, and 1.37 percent other new infections in the treated quarters, whereas there were 11.82 percent new staphylococcal infections, 3.04 percent new streptococcal infections, and 1.35 percent other new infections in the untreated quarters. In another trial, one treatment (0.5 gram benzathine cloxacillin) and a control were used to test the effectiveness of dry cow therapy in preventing infections. One hundred and eight right-side quarters were infused with 0.5 gram benzathine cloxacillin and teat dipped with an Iodophor disinfectant, while 106 left-side quarters were teat dipped only. There was no significant difference in new infections between treated and untreated quarters. New infections in the treated quarters were 12.0 percent compared to 12.3 percent in the untreated quarters. Ward and Schultz (1973) found that new infections were 5.6 percent in treated quarters (0.5 gram neomycin sulfate and teat dipping with a 1 percent Iodophor on one side of all cows once a day for seven days after drying off), compared to 9.5 percent new infections in the untreated quarters (teat dipping only on one side of all cows once a cay for seven days after drying off).

Kingwill et al. (1967) infused into each quarter of alternate cows at drying off 0.5 gram or 1.0 gram benzathine cloxacillin. Each quarter in the 0.5 or 1.0 gram benzathine cloxacillin groups were teat dipped with a 4 percent hypochlorite solution. Each treatment group had 3.6 percent of the quarters with new infections. Uvarov et al. (1967) studied the effect of 0.3 gram penicillin and 0.25 gram novobiocin preparation in three herds involving 384 quarters in preventing new staphylococcal infections during the dry period. Management and hygiene was satisfactory in one herd but not in the remaining two herds. A control group was not used for comparison. The antibiotic preparation was infused into all quarters at drying off to the cows in herds two and three, whereas in herd one all quarters were infused at drying off and again three weeks later. They found the proportion of quarters with new staphylococcal infections to average 5.8 percent in the three herds with very small difference among herds. Smith et al. (1967) compared two forms of cloxacillin (0.2 gram sodium cloxacillin and 1.0 gram benzathine cloxacillin) in preventing new quarter infections by calving. Both treatment groups had teats dipped in a hypochlorite solution (5 percent available chlorine). The 0.2 gram sodium cloxacillin group had 3.3 percent new infections, compared to 1.7 percent in the 1.0 gram benzathine cloxacillin group. There was 1.6 percent new Staph. aureus infections in the sodium cloxacillin group compared to 0.3 percent in the benzathine cloxacillin group; however, there was no difference in new streptococcal infections between the two cloxacillin treatment groups. Langley et al. (1971) conducted a trial involving 630 cows on 21 farms to test the effectiveness of three different antibiotic preparations in preventing infections during the dry period. The treatments consisted of (1) 0.5 gram benzathine cloxacillin, (2) 300,000 units penicillin and 0.25 gram sodium novobiocin, and (3) 300,000 units procaine benzylpenicillin and 250,000 units dihydrostreptomycin. No control group was used to measure treatment effects. All infused quarters were teat dipped with an Iosan solution (15,000 ppm available iodine). The benzathine cloxacillin group had 1.75 percent new Staph. aureus infections compared to 1.74 percent for penicillin plus sodium novobiocin group, and 2.99 percent for the procaine benzylpenicillin plus dihydrostreptomycin group. On one farm there was a significant difference in the number of new Staph.

aureus infections between two treatment groups (0.5 gram benzathine cloxacillin; 100,000 units penethmate hydriodide plus 300,000 units procaine penicillin plus 0.1 gram framycetin sulfate). All teats were dipped with an Iosan solution (15,000 ppm available iodine). They found 3.87 percent new Staph. aureus infections in the benzathine cloxacillin group, compared to 1.28 percent new staphylococcal infection in the mixed dry cow treatment group.

TABLE III

SUMMARY OF RESULTS ON DRY COW THERAPY

Researcher	No. of Cows or Quarters	Control Group	Criteria Measured	Antibiotic	Reduction in Mastitis Incidence
I. <u>Elimination</u>:					
Smith et al. (1966)	450 cows	Yes	% reduction in rate of existing infections (cows)	0.2g sodium cloxacillin	62.3
				1.0g benzathine cloxacillin	75.4
Kingwill et al. (1967)	534 quarters	Yes	% infections eliminated (quarters)	0.5g benzathine cloxacillin	
			Staphylococci		78%
			Streptococci		95%
				1.0g benzathine cloxacillin	
			Staphylococci		74%
			Streptococci		97%
Smith et al. (1967)	888 cows	Yes	% reduction in rate of existing infections (cows)	0.2g sodium cloxacillin	58.1
				1.0g benzathine cloxacillin	74.8
Langley et al. (1971)	363 quarters	Yes	% <u>Staph. aureus</u> infections eliminated (quarters)	0.5g benzathine cloxacillin	78.9%
Brookbanks (1968)					
Herd I	109 quarters	Yes	% infections eliminated (quarters)	0.5g benzathine cloxacillin	
			Staphylococci		75%
			Streptococci		100%
Herd II	73 quarters	Yes	Staphyloccocci	0.5g benzathine cloxacillin	48%
			Streptococci		100%
Pearson and Wright (1969)	366 quarters	Yes	% infections eliminated (quarters)		
			Staphylococci	0.2g sodium cloxacillin	75%
			Streptococci	0.3g procaine penicillin G	100%
			Staphyloccocci and Streptococci	0.25g novobiocin and 0.3 g procaine penicillin	75%
	285 quarters	Yes	Staphylococci	0.5g benzathine cloxacillin	56%
			Streptococci		100%

TABLE III (Continued)

Researcher	No. of Cows or Quarters	Control Group	Criteria Measured	Antibiotic	Reduction in Mastitis Incidence
Rosenzuaig and Mayer (1970)	448 quarters	Yes	% Staphylococcal infections eliminated	0.5g benzathine cloxacillin	61.4%
Eberhart and Buckalew (1972)	200 cows	Yes	% infections eliminated (quarters)	200,000 units procaine penicillin and 0.1g dihydrostreptomycin	
			Staphylococci		96%
			Streptococcus agalactiae		100%
			nonagalactiae Streptococci		80%
Brookbanks (1968)	95 quarters	No	% infections eliminated (quarters)	0.5g benzathine cloxacillin	
			Staphylococci		69%
			Streptococci		91.6%
			Staphylococci	0.3g penicillin G and	60%
			Streptococci	0.25g novobiocin	100%
Loosmore et al. (1968)	578 cows	No	% staphylococcal infections eliminated (quarters)	0.5g benzathine cloxacillin	62%
			% staphylococcal infections eliminated (quarters)	0.25g sodium novobiocin plus 300,000 units penicillin	64.1%
			% staphylococcal infections eliminated (quarters)	0.5g spiramycin	40.2%
Dodd et al. (1969A)	66 quarters	No	% infections eliminated (quarters)	0.2g sodium cloxacillin	
			Hemolytic staphylococci		83%
			Streptococci		76%
			Mixed Staphylococci and Streptococci		100%
Langley et al. (1971)	630 cows	No	% staphylococcal infections eliminated (quarters)	0.5g benzathine cloxacillin	73%
			% staphylococcal infections eliminated (quarters)	300,000 units penicillin and 0.25g sodium novobiocin	78%
			% staphylococcal infections eliminated (quarters)	300,000 units procaine benzylpenicillin and 250,000 units dihydrostreptomycin	62%

TABLE III (Continued)

Researcher	No. of Cows or Quarters	Control Group	Criteria Measured	Antibiotic	Reduction in Mastitis Incidence
II. Prevention:					
Oliver et al. (1962)	37 quarters	Yes	% reduction in rate of new infections	200,000 units procaine penicillin G and 200,000 units dihydrostreptomycin	83.35%
	37 quarters	Yes	% reduction in rate of new infections	100,000 units procaine penicillin G and 100,000 units dihydrostreptomycin	100%
Pearson and Wright (1969)	369 quarters	Yes	% reduction in rate of new infections	0.3g procaine penicillin G	15.5%
			% reduction in rate of new infections	0.5g benzathine cloxacillin	1.79
Thoreson (1973)	160 quarters	Yes	% reduction in rate of new infections	0.5g benzathine cloxacillin	0
Ward and Schultz (1973)	402 cows	Yes	% reduction in rate of new infections	0.5g neomycin sulfate	41%
Langley et al. (1971)	314 quarters	Yes	% reduction in rate of new staphylococcal infections	0.5g benzathine cloxacillin	45%
Smith et al. (1967)	1782 quarters	No	% reduction in rate of new infections	0.2g sodium cloxacillin	65.26%
				1.0g benzathine cloxacillin	82.11%
Eberhart and Buckalew (1972)	680 quarters	No	% reduction in rate of new infections	200,000 units procaine penicillin G and dihydrostreptomycin	56.11%
Rosenzuaig and Mayer (1970)	112 cows	No	% reduction in rate of new infections	0.5g benzathine cloxacillin	78.9%
Kingwill et al. (1967)	1510 quarters	No	% reduction in rate of new infections	0.5 and 1.0g benzathine cloxacillin	67.6%

TABLE III (Continued)

Researcher	No. of Cows or Quarters	Control Group	Criteria Measured	Antibiotic	Reduction in Mastitis Incidence
Uvarou et al. (1967)	384 quarters	No	% new staphylococcal infections	0.3g penicillin and 0.25g novobiocin	5.8%
Langley et al. (1971)	630 cows	No	% new staphylococcal infections	0.5g benzathine cloxacillin	1.75%
			% new staphylococcal infections	300,000 units penicillin and 0.25g sodium novobiocin	1.74%
			% new staphylococcal infections	300,000 units procaine benzulpenicillin and 250,000 units dihydrostreptomycin	2.99%

CHAPTER III

MATERIALS AND METHODS

This study consisted of experiments to test the effectiveness of antibiotic therapy and simple hygiene on prevent of new mastitis. Dairy cows and pre-parturient heifers from the Oklahoma State University dairy herd were used. Prior to drying-off, all cows were examined by collection of quarter milk samples for presence of mastitis causing bacteria, and were classified as infected or non-infected (negative) cows. Micrococci, Diphtheriods, or coagulase-negative *Staphylococcus epidermidis* were recorded as nonpathogens, and cows with quarters having these organisms were included in the experiment. All first calf heifers were assumed to be negative prior to assignment to experiment. Cows classified as infected were not included in the experiment because of an insufficient number of infected cows, and an abundance of data on the success of antibiotic therapy on elimination of infection.

Samples of milk from each quarter of all cows and first calf heifers were collected within one week after calving and again at about one month after calving. These samples were subjected to bacteriological examination within a few hours after collection. Treatments were considered successful if there was an absence of clinical signs and less than 200 colonies per milliliter of mastitis causing bacteria from two consecutive quarter milk samples during each sampling period.

Experiment I

Experimental Design

The experiment involved one hundred and sixty-four dairy cows (56 Ayrshires, 12 Guernseys, 23 Jerseys, and 73 Holsteins). The principal study was set up as a randomized block design where the experimental animals were blocked by lactation number (one, two, three or more) at the time of drying-off. Breed was ignored in assigning of experimental animals to particular blocks. Within each block, cows were randomly allotted to one of two treatments. When several cows were available for a particular block, the cow having the lowest neck chain number was assigned to the first available treatment and the remaining cows followed in numerical order. Cows ending a lactation period with an infected quarter or quarters shedding pathogenic bacteria were treated at drying-off and not included in the experiment. Cows were started on the experiment from July 11, 1972 to November 8, 1973, and the first cow on the experiment calved on July 30, 1972.

Treatments

Cows were randomly allotted to one of two treatments. The two treatments were: (1) control, no infusion and (2) an intramammary infusion of 500 mg benzathine cloxacillin[a] into each quarter after the last milking of the lactation period. Benzathine cloxacillin is a semi-synthetic penicillin in a long-acting peanut oil vehicle, which is

[a]Bristol Laboratories, Division of Bristol-Myers Co., Syracuse, New York.

resistant to destruction by the enzyme, penicillinase. Quarters of all cows were teat dipped with a iodine solution[b] (10,000 ppm available iodine) once a day for seven days after drying-off.

Managment of Cows

Nine days prior to drying-off cows were separated from the miling herd. These cows were placed in an open drylot with limited pasture, so they could be dried off gradually. Alfalfa hay was provided while cows were being dried off. After drying-off the dry cows were grouped in a small closed pasture for seven days for teat dipping purposes. Cows received alfalfa hay and a limited amount of sorghum silage concentrate mixture. A quonset hut was located in the north section of the pasture which provided protection against inclement weather. Following the seven days in the closed pasture the dry cows were moved to native range pasture and allowed to graze. Approximately one month prior to the expected date of next calving, the cows were returned to a pasture near the milking facilities and accustomed to the milking herd ration. The pasture was relatively dry for most of the year. Cows were allowed to calve in the pasture or in a quonset hut during the entire year. The calves remained with the cows until the next milking. For three or four days after calving, the freshened cows were kept separate from the milking herd. Periodic inspection of the cows was made throughout the dry period, examining udders for signs of clinical mastitis such as swelling, inflammation, heating, and painful quarters.

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[b]"Bovadine," West Agro-Chemical Products, Inc., Subsidiary of West Chemical Products, Inc., Long Island, New York.

A standard managment program for lactating cows was followed for the entire experiment. This included proper maintenance of milking equipment, use of strip cup for detection of clinical mastitis before each milking, treatment of clinical cases of mastitis during lactation, and the use of an acceptable milking technique. Experimental animals were not separated from the milking herd during the lactation. Lactating cows were grouped in open pastures, fed a ration consisting of sorghum silage, a concentrate mixture, alfalfa hay, and native pasture. A twelve hour milking interval was maintained throughout the experiment. Experimental animals were not milked at designated times. Sick cows were housed separately in a drylot near the milking facilities and were milked first. Following milking of the sick cows, the milking equipment was flushed with warm water. The cows were milked with a Surge-Randal low line milking system consisting of a double "three-in-line" with side opening stalls. A partial hygiene system was practiced. The system included: flushing milking lines with a sodium hypochlorite disinfectant[a] (10.25 percent chlorine by weight) prior to every milking, automatic system of cows udders upon entering the milking parlor with a water rinse containing an approved germicide,[b] drying each udder with single service paper towels, and teat dipping with an iodine solution[c] (10,000 ppm available iodine) after each milking.

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[a]"Zinicin," Babson Bros., Co., Oakbrook, Illinois.

[b]"Surge Udder Cleanitizer," Central Oklahoma Surge Co., subsidiary of Babson Bros. Co., Oakbrook, Illinois.

[c]"Bovadine," West Agro-Chemical Products, Inc., Subsidiary of West Chemical Products, Inc., Long Island, New York.

Collection of Data

Status of infection was determined by bacteriological examination of quarter milk samples at drying-off, 4 to 10 days post-partun, one month post-partun, and whenever clinical mastitis was detected. Samples of foremilk from each quarter were taken at drying-off to examine for presence of mastitis causing pathogens. The foremilk samples from each quarter were collected in a series of three on two consecutive sampling days. The first quarter sample consisted of a single sample of foremilk from each quarter taken at either a Tuesday or Thursday morning milking. The second and third quarter sample consisted of a duplicate sample of foremilk from each quarter taken on the subsequent Tuesday or Thursday morning milking. A similar procedure was employed within 4 to 10 days after freshening and one month after freshening.

Samples of foremilk were collected using aseptic procedures which included washing udders, drying udders prior to sampling with individual paper towels, scrubbing the teat end and orifice thoroughly with 70 percent ethyl or isopropyl alcohol before sampling, and taking samples prior to attachment of the milking machine. The teats located on the opposite side from the sampler were cleaned first, so that recontamination of teat ends closest to the sampler would not occur. Samples were taken first from the teates on the side nearest the sampler. Clinical mastitis was detected in the dry period by observation of redness, swelling, and painful quarters. Furthermore bypalpation of the udder heating was detected. During the lactation clinical mastitis was observed by strip cup. When clinical mastitis was detected in the lactation or dry period, a duplicate sample of foremilk from each quarter was taken before treatment, using the same aseptic procedures mentioned above.

Laboratory Procedures

Approximately 3ml of foremilk were collected in either 18 ml. sterile glass test tubes with screw-up caps or 18 x 150 ml. sterile glass test tubes with metal push on caps. The samples were cultured within 4 hours following the sampling period. After shaking the samples for five seconds with a mechanical mixer,[a] 0.02 ml. of milk was streaked onto 5 percent bovine blood agar in a 10 cm. diameter petri dish. One-half of the petri dish was used per quarter sample. Each dish was appropriately marked with the cow number, quarter number (1-RR, 2-RF, 3-LF, 4-LR), and the type of sample collected (drying-off, freshening, one month post-freshening, or clinical). Each plate was designated as the single sample or one of the duplicate samples (A or B). After twenty-four hours of incubation at $37^{\circ}C$, the plates were examined for the number of colony forming units of Streptococci, Staphylococci, or other organisms. An individual bacteriological record was kept for the three samples from each cow. The number of colonies were recorded, and the plates were incubated for an additional twenty-four hours and observed for growth of additional colonies. Procedures to identify specific groups or species of mastitis causing microorganisms were those published by the Research Committee of the National Mastitis Council (Brown et al., 1969).

The committee defined infected quarters as those showing 200 or

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[a]"Deluxe Mixer," Scientific Products, Division of American Hospital Supply, Corp., McGraw Park, Illinois.

more colony forming units per ml. of secretion. A quarter was recorded infected only when the same pathogen was isolated from two consecutive samples, or from each of the duplicate samples.

Experiment II

Experimental Design

Pre-parturient heifers from the Oklahoma State University dairy herd were used for the experiment. Animals were assigned at random to one of two treatments two weeks prior to the expected date of calving. When several heifers were available for assignment to a treatment, the heifer with the lowest neck chain number was assigned to the first available treatment and the remaining heifers followed in a numerical order.

Treatments

Each of 64 pre-paturient heifers was assigned randomly to one of two treatments: (1) control, no teat dipping and (2) teat dipping of each quarter with an iodine solution[a] (10,000 ppm available iodine) once a day starting two weeks prior to the expected date of calving and continuing until the animal calved.

Sampling Procedure

Samples of foremilk were taken at 4 to 10 days, or whenever

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[a]"Bovadine," West Agro-Chemical Products, Inc., Subsidiary of West Chemical Products, Inc., Long Island, New York.

clinical mastitis was detected on the strip cup prior to regular sampling period. Bacteriological examination of each quarter sample was performed to determine whether mastitis causing pathogens were present. The procedures for sampling and laboratory technique were the same as those used in experiment I.

Managment

Pre-paturient heifers assigned to the treatment group were separated at two weeks prior to the expected date of calving from the control group and maintained in an open drylot near the teat dipping facilities until calving, whereas heifers in the control group were kept in a separate open drylot. Both the treatment and control groups were maintained under the same environmental conditions. Pre-parturient heifers were fed a ration consisting of sorghum silage, a 12 percent crude protein concentrate mixture, and alfalfa hay (except summer).

CHAPTER IV

RESULTS AND DISCUSSION

Experiment I

New Infections

Three lactation blocks were analyzed separately to determine the value dry cow treatment would provide in reducing the incidence of new infections (Table IV). Only in the group with 3 or more lactations was there a statistically significant ($P < .05$) reduction in new infections due to dry cow treatment. In cows with one and two previous lactations the reduction in new infections only approached significance ($P < .12$). A possible reason for the lack of significant differences between the treated and control cows in the first and second lactation blocks was the relatively small number of cows in these categories and, consequently, a very small difference in number of infections.

Only 1 of 19 new infections was detected during the dry period. It was not possible to determine when the 18 infections first detected 4 to 10 days post calving initially occurred. The possibility exists that a high percent of these infections in both treated and control cows were in fact infections that occurred following calving. This latter possibility was strongly suggested by Neave et al. (1967).

When more than one quarter of a cow becomes infected during a non-lactating period, mastitis becomes a greater economical problem to the

TABLE IV

NUMBER OF NEGATIVE COWS DEVELOPING INFECTIONS DURING THE DRY PERIOD

Items	Lactations					
	One		Two		Three or More	
Treatments	C[a]	T[b]	C	T	C	T
Number of Cows	30[c]	30	22	22	29	31
New clinical infections during the dry period	0	0	0	0	1	0
Additional infections detected upto 4 to 10 days post-partun	3	0	7	2	5	1
Total infections	3	0	7	2	6	1*
Percent cows infected	10	0	31.8	9.1	20.7	3.2
Percent reduction in new infections	100		71.4		84.5	

[a]Control, no infusion.

[b]Treated, infused into each quarter of designated cows at drying-off with 500 mg benzathine cloxacillin.

[c]One blind quarter.

*Treated group significantly different from control group in same lactation, $P < .05$.

dairy producer than if only one quarter is infected. Therefore, it seemed appropriate to consider each quarter as a separate functional unit in testing the effect of drug therapy in preventing infections (Table V). There was a greater number of infections in the control quarters than in the treated quarters for lactation block one, which approached statistical significance ($P < .12$). Infection rate in treated quarters was significantly lower in lactation block two ($P < .05$) and three ($P < .01$) than in the control quarters.

A test for interaction between lactation number and treatment effects was conducted to determine whether all lactations could be pooled. Lactation number had no effect on the incidence of infections in the drug therapy group ($P > .5$). Similarly, lactation number was found not to increase the incidence of infections in the control group ($P > .25$). On this basis, it was concluded that there was a lack of interaction between lactation number and treatment effects. Upon finding that lactation number had no effect on treatment differences, all lactations were pooled to determine whether or not a difference existed between treated and control cows (Table VI). By pooling all lactations, a clearer picture evolves concerning the value of dry cow treatment. The number of cows with new infections determined by 4 to 10 days after calving was significantly reduced ($P < .001$) by drug therapy. Sixteen of 81 control cows (19.7 percent) and 3 of 83 treated cows (3.6 percent) became infected by 4 to 10 days after freshening. The number of quarters with new infections was also significantly different ($P < .0001$) between treated and control groups (Table VII). In the treated quarters, 4 of 332 (1.2 percent) new infections developed compared to 22 of 323 (6.8 percent) of the control quarters.

TABLE V

NUMBER OF NEGATIVE QUARTERS DEVELOPING INFECTIONS DURING THE DRY PERIOD

Items	Lactations					
	One		Two		Three or More	
Treatments	C[a]	T[b]	C	T	C	T
Number of quarters	119[c]	120	88	88	116	124
New clinical infections during the dry period	0	0	0	0	2	0
Additional infections detected upto 4 to 10 days post-partun	3	0	11	3	6	1
Total infections	3	0	11	3*	8	1**
Percent quarters infected	2.5	0	12.5	3.4	6.9	0.8
Percent reduction in new infections	100		72.8		88.4	

[a]Control, no infusion.

[b]Treated, infused into each quarter of designated cows at drying-off with 500 mg benzathine cloxacillin.

[c]One quarter blind.

*Treated group significantly different from control group in same lactation, $P < .05$.

**$P < .01$.

TABLE VI

NUMBER OF NEGATIVE COWS (POOLED) DEVELOPING INFECTIONS DURING THE DRY PERIOD

Items	Lactations	
	Control[a]	Treated[b]
Number of cows	81[c]	83
New clinical infections during the dry period	1	0
Additional infections detected upto 4 to 10 days post-partum	15	3
Total infections	16	3
Percent new infections	19.7	3.6***
Percent reduction in new infections	81.8	

[a]Control, no infusion.

[b]Treated, infused into each quarter of designated cows at drying-off with 500 mg benzathine cloxacillin.

[c]One blind quarter.

***Treated group significantly different from control group, P < .001.

TABLE VII

NUMBER OF NEGATIVE QUARTERS (POOLED) DEVELOPING INFECTIONS DURING THE DRY PERIOD

Items	Lactations	
	Control[a]	Treated[b]
Number of quarters	323[c]	332
New clinical infections during the dry period	2	0
Additional infections detected upto 4 to 10 days post-partum	20	4
Total infections	22	4****
Percent new infections	6.8	1.2
Percent reduction in new infections	82.4	

[a]Control, no infusion.

[b]Treated, infused into each quarter of designated cows at drying-off with 500 mg. benzathine cloxacillin.

[c]One blind quarter.

***Treated group significantly different from control group, $P < .0001$.

The percent reduction in rate of new infection was determined as the difference in the percent infection rate between treated and control groups divided by the percent infection rate in the control group: % reduction = (Difference in % infection rate in control and treated groups/% infection in control group) x 100. On this basis, there was an 81 percent reduction in cows developing new infections and an 82 percent reduction in number of quarters with new infections.

The percent reduction in new infections in the present study agrees closely with the results of Oliver et al. (1962) who also noted an 83 percent reduction in new infections with procaine penicillin G and dihydrostreptomycin treatment (Table III). Even a greater reduction (100 percent) was reported where quarters were treated with half the dose used in the above comparison. Ward and Schultz (1973) reported less reduction, i.e., 41 percent, by infusing neomycin sulfate. Sanderson (1966) and Uvarov (1971) reported that neomycin was ineffective for mastitis therapy; therefore, less reduction noted by Ward and Schultz (1973) could be explained by the ineffectiveness of neomycin against gram-positive microorganisms. Langley et al. (1971) found 45 percent reduction in new Staph. aureus infections by infusing benzathine cloxacillin. The relatively low reduction in infection rate may have been due to within-cow cross infection which lowered the apparent effectiveness of the benzathine cloxacillin.

Other workers (Pearson and Wright, 1969; Thoreson, 1973) obtained bery little or no reduction in infection rate by infusion. In one experiment, Pearson and Wright (1969) initiated treatment part way through the nonlactating period. One possible explanation for very little reduction in infection rate in the second experiment by Pearson and Wright

(1969) may be within-cow infection. Complete lack of reduction by Thoreson (1973) may have been due to poor milking facilities used during remodeling which allowed a high rate of new infections within a few days after calving. There was no definite relationship between level of infection in the herds, as measured by infection rate in controls, and the percent reduction in new infections due to antibiotic therapy. Other factors which may influence the efficiency of dry cow therapy include cows refractoriness to treatment, and does, base, and salt of the various antibiotic preparations.

Some other investigators (Smith et al., 1967; Eberhart and Buckalew, 1972; Rosenzuaig and Mayer, 1970) have reported reductions in rate of new infection from 56 to 82 percent where antibiotic infusion plus teat dipping was compared to controls having neither of these. The validity of these reductions are questioned as to whether just antibiotic treatment or a possible additive effect between antibiotic treatment and teat dipping actually caused the reduction in the rate of new infections. The combination of the two variables would not be comparable with the present study having just one variable. Smith et al. (1967) reported a reduction in rate of new infection of 82 percent by infusing with benzathine cloxacillin and teat dipping. Furthermore, a reduction in rate of new infections of 65 percent resulted from infusion of sodium cloxacillin plus teat dipping. One possible reason for the less reduction in the latter study could be due in part to the short duration of cloxacillin as the sodium salt in th- dry udder. Rosenzuaig and Mayer (1970) obtained a 79 percent reduction in new infections with benzathine cloxacillin and teat dipping. No explanation was provided for the lower reduction, i.e., 56 percent reported by Eberhart and

Buckalew (1972).

Other investigators (Kingwill et al., 1967) reported a similar rate of new infection in cows infused with either 1.0g or 0.5g benzathine cloxacillin and teat disinfection. However, the rate of new infection in the treatment groups was compared to the rate of new infection from a control group in a previous study. The validity of a direct comparison without a simultaneous control on the reduction in rate of new infection with benzathine cloxacillin and teat disinfection may be questioned. The rate of new infection in the treated quarters may have been influenced by differences in herds, or post-calving sampling routine.

How Detected

The majority of the new infections by 4 to 10 days post-calving were determined by bacteriological examination of quarter milk samples (Table VIII). There were 14 of 19 (73.7 percent) new infections in cows determined bacteriologically, whereas only 5 of 19 (26.3 percent) were clinical cases of mastitis. Seventeen of 26 (65.4 percent) new infections in quarters were detected by bacteriological examination, and only 9 of 26 (34.6 percent) new infections by observation of clinical mastitis. Similarly, Edwards and Smith (1967) found 20.5 percent of the new infections in cows at subsequent calving were detected by clinical observation. On the contrary, Thoreson (1973) reported 93 percent of the mastitis infections in cows, and 90.9 percent of infected quarters were determined by clinical observation. One possible explanation for the greater occurrence of clinical mastitis in work by Thoreson (1973) than in the present study may have been that poor milking

TABLE VIII

INFECTIONS DETERMINED BY BACTERIOLOGICAL OR CLINICAL MEANS

Method	No.	%	Total Clinical	Total Bacteriological
Cows				
Bacteriological only	14	73.7	----	89.5
Bacteriological and clinical	3	15.8	26.3	----
Clinical only	2	10.5		
	19			
Quarters				
Bacteriological only	17	65.4	----	76.9
Bacteriological and clinical	3	11.5	34.6	----
Clinical only	6	23.1		
	26			

facilities were used during remodeling.

It appears that only about one-fourth of the new infections would be detected by observation of clinical mastitis. Dairy producers would have to bacteriologically examine quarter milk samples from all freshened cows in order to determine the major portion of new infections. Unless a free service were provided to dairy producers to test milk for presence of mastitis causing pathogens, the majority of new infections would not be detected and allow to advance to a higher stage of pathogenicity, possibly causing more severe damage during the ensuing lactation.

Types of Bacteria Isolated

Treating cows with 500 mg. benzathine cloxacillin did not appear to influence the type of bacteria isolated throughout the study (Table IX). Dry cow treatment did not cause an increase in the occurrence of new infections with less common types of bacteria. Of special interest was the 6 cases of clinical mastitis in the control group, compared to none in the treated group, which were negative upon bacteriological examination. Some investigators (Wesen and Schultz, 1970; Eberhart and Buckalew, 1972) suggest that cases of clinical mastitis which upon bacteriological examination are negative may be due to a high incidence of acute coliform in fection with leukocytes in the clinical quarter eliminating the pathogens, or to a virus or injury where no pathogenic bacteria are present. Similarly, Oliver et al. (1962), Sanderson (1966), Pearson and Wright (1969), and Eberhart and Buckalew (1972) found that drug therapy during the dry period did not increase the appearance of the less common types of bacteria which cause mastitis.

TABLE IX

EFFECT OF TREATMENT ON TYPE OF BACTERIA ISOLATED FROM QUARTERS UPTO 4 TO 10 DAYS POST-CALVING AND IN THE SUBSEQUENT PERIOD UPTO 30 DAYS POST-CALVING

Item	4 to 10 Days Post-Calving		First 30 Days Post-Calving	
	Control[a]	Treated[b]	Control[a]	Treated[b]
No. of Quarters	323[c]	332	260[c]	316
Type of Bacteria:				
Staphylococcus aureus	8	3	2	3
Streptococcus uberis	6	1	1	2
Streptococcus dysgalactiae	0	0	1	2
Streptococcus species	1	0	0	1
Corynebacterium pyogenes	1	0	0	0
Pseudomonas aerugenosa	0	0	0	2
Klebsiella sp.	0	0	0	1
Mixed *Staphylococcus aureus* and *Streptococcus dysgalactiae*	0	0	0	1

[a]Control, no infusion

[b]Treated, infused into each quarter of designated cows with 500 mg. benzathine cloxacillin at drying-off,

[c]One blind quarter.

New Infections in Early Lactation

Sampling was continued for the first 30 days of the lactation period to determine whether dry cow treatment would cause an increase in number or change the type of organisms involved in new infections (Table X). Only cows negative at 4 to 10 days after calving were included. There was not a significantly higher percentage of new infections in the treated cows than in the control cows, i.e., 11.4 percent compared to 9.2 percent, respectively. Likewise, the difference in new infections in the treated and control quarters was not statistically significant ($P > .5$) (Table XI). Cows developed new infections from calving to 30 days post-calving with the same types of pathogenic bacteria present in the herd prior to treatment at drying-off.

A few investigators (Edwards and Jones, 1966; Natzke, 1971; Brown et al., 1972) suggested that untreated quarters at drying-off which posses non-pathogenic bacteria may have a lower rate of new infection than treated quarters in the ensuing lactation. They theorized that the presence of non-pathogenic bacteria in the untreated quarter may initiate the formation of 300,000 to 500,000 somatic cells per milliliter of milk which would act as an effective barrier against invasion into the udder of certain pathogenic bacteria.

Experiment II

New Infections

No evidence of a beneficial effect was found from teat dipping heifers prior to first calving (Table XII). Eleven of 31 treated heifers (35.5 percent) and 10 of 35 control heifers (28.6 percent) had

TABLE X

NUMBER OF NEGATIVE COWS (POOLED) DEVELOPING INFECTIONS DURING THE PERIOD FROM THE FIRST POST-CALVING SAMPLING UPTO 30 DAYS OF THE LACTATION PERIOD

Item	Lactations	
	Control[a]	Treated[b]
Number of cows negative a 4 to 10 days post-calving	65	79
Additional infections developing upto 30 days post-calving	6	9
Percent of new infections	9.23	11.39

[a]Control, no infusion.

[b]Treated, infused into each quarter of designated cows at drying-off with 500 mg. benzathine cloxacillin.

TABLE XI

NUMBER OF NEGATIVE QUARTERS (POOLED) DEVELOPING INFECTIONS DURING THE PERIOD FROM THE FIRST POST-CALVING SAMPLING UPTO 30 DAYS OF THE LACTATION PERIOD

Items	Lactations	
	Control[a]	Treated[b]
Number of quarters negative at 4 to 10 days post-calving	260[c]	316
Additional infections developing upto 30 days post-calving	6	12
Percent of new infections	2.3	3.8

[a]Control, no infusion.

[b]Treated, infused into each quarter of designated cows at drying-off with 500 mg. benzathine cloxacillin.

[c]One blind quarter.

TABLE XII

NUMBER OF FIRST CALF HEIFERS DEVELOPING INFECTIONS
UPTO 4 TO 10 DAYS POST-CALVING

Treatments	Not dipped[a]	Dipped[b]
Number of heifers	35[c]	31[c]
New infections developing by 4 to 10 days post-calving	10	11
Percent heifers infected	28.6	35.5

[a]Control, no teat dipping.

[b]Treated, each quarter of designated heifers teat dipped for approximately 12 days prior to the expected date of calving with a Bovadine solution (10,000 ppm available iodine).

[c]Clinical case may have been due to injury.

new infections by 4 to 10 days after calving. Likewise, there was no significant difference (P > .6) between treated and control quarters in the number of new infections (Table XIII). In the treated quarters, 13 of 122 (10.7 percent) new infections developed compared to 19 of 140 (13.6 percent) of the control quarters. Lack of any beneficial effect from teat dipping pre-parturient heifers may have been due to the fact that infections had developed earlier than two weeks prior to the expected date of calving. Palmer et al. (1941) found heifers to be infected three weeks prior to calving. Other investigators (Palmer et al., 1941; Schalm, 1942; Brown et al., 1965) suggested that calves fed milk from infected cows and allowed to suckle penmates may develop infections during calfhood. Hopkirk (1972) suggested that late calving heifers may readily contract mastitis due to increased intramammary pressure leading to leakage of milk allowing passage of pathogenic bacteria into the teat canal and gland cistern. Another possible explanation may be that a high percent of the infections determined by 4 to 10 days after calving in the treated and control heifers were infections that occurred following calving. On the contrary, Munch-Petersen (1968) found that the percent of first calf heifers negative at calving in 3 experimental herds were 81.5, 84.5, and 93.3 percent, respectively.

<u>How Detected</u>

The majority of new infections were determined by bacteriological examination of quarter milk samples by 4 to 10 days post-calving, rather than by observation of clinical mastitis (Table XIV). There were 14 of 21 (66.7 percent) new infections in heifers determined bacteriologically, whereas only 7 of 21 (33.3 percent) new infections

TABLE XIII

NUMBER OF QUARTERS DEVELOPING INFECTIONS
UPTO 4 TO 10 DAYS POST-CALVING

Treatments	Not Dipped[a]	Dipped[b]
Number of quarters	140[d]	122[c,d]
New infections developing by 4 to 10 days post-calving	19	13
Percent quarters infected	13.6	10.7

[a]Control, no teat dipping.

[b]Treated, each quarter of designated heifers teat dipped for approximately 12 days prior to the expected date of calving with a Bovadine solution (10,000 ppm available iodine).

[c]Two blind quarters.

[d]Clinical case may have been due to injury.

TABLE XIV

INFECTIONS DETERMINED BY BACTERIOLOGICAL OR CLINICAL MEANS

Method	No.	%	Total Clinical	Total Bacteriological
First Calf Heifers				
Bacteriological only	14	66.7	----	85.7
Bacteriological and clinical	4	19.0	33.3	----
Clinical only	3	14.3		
	21			
Quarters				
Bacteriological only	21	65.6	----	87.5
Bacteriological and clinical	7	21.9	34.4	----
Clinical only	4	12.5		
	32			

were detected by observation of clinical mastitis. Twenty-one of 32 (65.6 percent) new infections in quarters were detected by bacteriological examination of quarter milk samples, and only 11 of 32 (34.4 percent) were detected by clinical cases of mastitis.

Type of Bacteria Isolated

Typical strains of bacteria were isolated from treated and control heifers throughout this study (Table XV). Teat dipping did not appear to influence the occurrence of less common types of bacteria. *Staph. aureus*, *Strep. dysgalactiae*, and *Strep. uberis* were the pathogenic bacteria most frequently isolated. Palmer et al. (1941) reported that *Staph. aureus* was the predominant causative agent of mastitis in first calve heifers. Schalm (1942) found that *Strep. agalactiae*, *Strep. uberis*, and *Strep. dysgalactiae* were the causative agents in new infections. Similarly, Munch-Petersen (1968) found that common types of bacteria were isolated from first calf heifers after calving. Similarly, the bacteria isolated from infected first calf heifers in the present study were the same types as occurred in older cows in the herd.

TABLE XV

EFFECT OF TREATMENT ON TYPE OF BACTERIA ISOLATED FROM QUARTERS UPTO 4 TO 10 DAYS POST-CALVING IN HEIFERS

Organisms	Control	Treated
Staphylococcus aureus	5	7
Streptococcus species	1	2
Streptococcus dysgalactiae	8	2
Streptococcus uberis	2	0
Mixed *E. coli* and *Klebsiella*	0	1

CHAPTER V

SUMMARY AND CONCLUSION

One experiment was conducted to evaluate the effect of antibiotic infusion during the non-lactating period on preventing new mastitis infections in dairy cows under climatic and management conditions prevailing in the Southwest. A second experiment was undertaken to test the effectiveness of teat dipping pre-parturient heifers on preventing new infections before freshening.

In Experiment I, infusion of each quarter with 500 mg benzathine cloxacillin significantly reduced ($P < .001$) the rate of new infection up to 4 to 10 days post-calving. Rate of new infection was 19.7 percent in control cows and 3.6 percent in treated cows. Moreover, a significant reduction ($P < .0001$) was found between treated and control quarters, (6.8 percent compared to 1.2 percent, respectively). Seventy-four percent of the new infections in cows and 65 percent in quarters were detected only by bacteriological examinations of quarter milk samples. Dry cow treatment did not increase the appearance of new infections with less common types of bacteria. No significant difference ($P > .05$) was found between treated and control cows or quarters in incidence of new mastitis infections in the period from the first post-calving sampling up to 30 days of lactation.

In Experiment 2, no beneficial effect was found from teat dipping heifers prior to first calving. There were 13.6 percent new infection rate in control quarters and 10.7 percent in treated quarters (P > .05). Seventy-seven percent of the new infections in heifers and 66 percent in quarters were determined only by bacteriological examination.

In conclusion, it appears that infusion of 500 mg. benzathine cloxacillin in each quarter of cows free of infection at drying-off would prevent new infections from developing during the non-lactating period. Dipping of teats for seven days after drying-off with an effective disinfectant also appears to have merit in the prevention of new dry period infections. However, dipping teats of pre-parturient heifers each day for two weeks prior to calving does not seem to be a worthwhile endeavor in preventing new mastitis infections.

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