

NOCARDIA AND ACTINOMYCES AS CAUSATIVE AGENTS OF BOVINE MASTITIS: A REVIEW¹

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Mastitis still prevails as a major herd health problem—thus supplying concrete evidence that the era of antibiotics and vaccinations has not yielded the “cure-all” results which had been hoped for when such treatments were put into general use several years ago. In fact, there is increasing suspicion that instead of alleviating the mastitis problem, antibiotic practices have created a somewhat more difficult situation by causing a change in the predominant types of organisms responsible for udder infections. For example, some years back, mastitis was generally attributed to *Streptococcus agalactiae*. Now, due to antibiotic therapy, staphylococci and other organisms such as *Nocardia* and *Actinomyces* have reportedly assumed a greater role. This review is presented for the purpose of indicating the significance of the latter two organisms as causative agents of bovine mastitis.

TRENDS IN ORGANISMS CAUSING MASTITIS

Drury and Murray (5) in 1959, found that the organisms involved in mastitis in a Michigan area included 58.8% streptococci, 39.4% staphylococci, and 1.8% other organisms. In this same area in 1939, about 98% of the mastitis causative organisms were streptococci. Niksch, *et al.* (12) reported on 3137 milk samples from 582 herds in different areas of the United States in which mastitis had not responded satisfactorily to antibiotic treatment. They found the following organisms to be involved: staphylococci, 50.9%; streptococci, 25.9%; *Escherichia coli*, 5.9%; *Corynebacterium*, 5.6%; *Pseudomonas aeruginosa*, 1.9%; *Klebsiella*, 1.2%; and other possible pathogens, 3.5%. Since 1957, Pier and associates (13, 14, 15) have reported several instances in which *Nocardia asteroides* was involved in outbreaks of mastitis in California and Hawaii.

Recently, in Ohio, *Nocardia alba* and *Nocardia flavescens* were identified as being the cause for a case of serious udder infections in one herd (17).

CHARACTERISTICS OF *Nocardia* AND *Actinomyces*

The *Nocardia* are obligately aerobic microorganisms of the family *Actinomycetaceae*, and the *Actinomyces*

are anaerobic or microaerophilic members of the same family. Both are commonly referred to as actinomycetes, and are considered to be a group of microorganisms which are intermediate between true fungi and true bacteria because they possess some characteristics of both groups. *Nocardia* are free living in nature, whereas the *Actinomyces* are strict parasites of man and animals. Several species of *Nocardia* may enter directly into wounds to cause localized infections, and *Nocardia asteroides* may be inhaled to cause a primary pulmonary disease in man which can eventually move to any area of the body, particularly to the subcutaneous tissue and the central nervous system. There are only three recognized species of the genus *Actinomyces*, but all three are pathogenic to man and animals (2, 6).

SIGNIFICANCE OF *Nocardia* AND *Actinomyces* IN MASTITIS

The increasing incidence of fungus infections of both man and animals has been emphasized by the American Veterinary Medicine Association (1). *Actinomyces* was cited as an example of an organism which has appeared more often as a secondary invader after bacterial infections have been reduced with antibiotics. This trend appears to be similar to the reported incidences of *Nocardia* and *Actinomyces* in mastitis. A chronological summary of some of the reported incidences of these organisms in mastitis is presented in Table 1.

The data reveal that reported incidences of nocardial and actinomycotic infections in dairy herds occurred only in isolated cases until Pier and associates (13) diagnosed the disease in 16 of 29 cows of a single dairy herd in the Southern California area in 1957. Since that time the disease has been diagnosed in 9 additional dairy herds by these workers: six herds in California and three in Hawaii (14, 15). Losses due to *Nocardia asteroides* mastitis totaled 300 cows out of a 700 cow herd and 180 cows out of a 500 cow herd in Hawaii. In one California herd, 56 cows out of 157 were lost. The disease was diagnosed as severe in these cases. In other herds where the disease was detected, the infection was less severe and resulted in a considerable lower incidence of loss. Experimental reproduction of the disease in test animals was accomplished with the isolated *Nocardia asteroides*.

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TABLE 1. REPORTED INCIDENCES OF *Nocardia* AND/OR *Actinomyces* IN UDDER INFECTIONS

Research worker (s)	Year reported	Organism isolated	Type of animal	No. of animals infected	No. of herds	% of animals infected
Evans (7)	1918	<i>Nocardia asteroides</i>	cows	18	1	
Smith (18)	1934	actinomycotic species	cows	2	1	
Gray (8)	1935	<i>Actinomyces farctinica</i>	cow	1	1	
Hardenbrook (9)	1946	<i>Actinomyces species</i>	cows	Frequently isolated		from udders
Munch-Petersen (11)	1954	<i>Nocardia asteroides</i>	cow	1	1	
Pier, et al. (13)	1957	<i>Nocardia species</i>	cows	16	1	58
Jungerman (10)	1958	<i>Nocardia asteroides</i>	cows	several	1	
Defaala & Gharib (3)	1958	<i>Nocardia asteroides</i>	goat	1		
Pier, et al. (14)	1958	<i>Nocardia asteroides</i>	cows	28	1	18
Ditchfield, et al (4)	1959	<i>Nocardia braziliensis</i>	cows	1	1	
Pier, et al. (15)	1961	<i>Nocardia asteroides</i>	cows	560	6	36
Pounden & Martin (17)	1961	<i>Nocardia alba</i> & <i>Nocardia flavescens</i>	cows	3	1	

HABITAT OF *Nocardia*

Pier, et al. (16) have reported studies designed to determine the sources of nocardial infection in dairy herds. From the premises where the cattle contracted the disease, *Nocardia asteroides* was isolated from the soil, infusion cannulas, medicine vials, and from partially used drug infusion mixtures. When the organism was experimentally added to drug infusion mixtures it remained viable for 7 weeks, and a clinical response typical of the naturally occurring infection could be observed following infusion of these experimentally contaminated mixtures into the mammary gland of a non-lactating cow. The infection rate could be alleviated by the institution of proper aseptic techniques and the substitution of disposable single-dose applicators for multiple-dose drug mixtures.

HEAT RESISTANCE

Several investigators have reported thermal death studies with the isolated organisms (7, 11, 14). Evans (7) found the *Nocardia* organism isolated from infected udders to be killed by a temperature of 56°C for 30 minutes after it had remained in whole milk for 8 days. The 8-day culture was assumed to contain organisms as resistant to heat as would occur in milk at the time of pasteurization; consequently, it was concluded that normal pasteurization treatment was sufficient to kill the organism. Munch-Petersen (11) reported that the thermal death point of *Actinomyces (Nocardia) asteroides* grown at 37°C for 7 days in skim milk was 10 minutes at 70°C. Pier and associates (14) determined that *Nocardia asteroides* isolated from mastitis cases survived exposure to 64°C for 30 minutes. Smith (18) did not report specific thermal death studies, but stated that the milk from cows suffering from mastitis caused

by the actinomycotic species of organisms might present public health problems to consumers.

RESISTANCE TO ANTIBIOTICS AND GERMICIDES

Defaala and Gharib (3) observed the apparent ineffectiveness of antibiotics against *Nocardia asteroides*. Penicillin was infused into the infected udder of a goat for 6 days without effect, and, later, a mixture of penicillin and terramycin was included with no observed improvement. Bacteriological tests showed the organism involved to be resistant to penicillin, terramycin and streptomycin. Jungerman (10) found that when cows infected with *Nocardia asteroides* were treated with antibiotics the inflammatory process apparently became more severe. Ditchfield, et al. (4) reported a case of chronic mastitis due to *Nocardia braziliensis* which did not respond satisfactorily to any commercial mastitis preparation.

According to Pier, et al. (14), none of the more commonly used antibiotics were effective against *Nocardia asteroides*. These included penicillin, streptomycin, chloramphenicol, polymixin, neomycin, and three tetracycline derivatives. However, the antibiotics novobiocin (albamycin) and nitrofurazone (furacin) were effective against the organism, and erythromycin exhibited limited effectiveness. A mixture of novobiocin (500mg) combined with 25 to 40 cc of nitrofurazone solution (0.2%) was used successfully in treating infected udders. Common dairy disinfectants which were practically ineffective against the organism were iosan and nolvasan. However, satisfactory bacterial destruction was obtained with chlorine, 100 ppm and exposure time of 5 minutes, and Roccal, 100 ppm for 10 minutes or 200 ppm for 5 minutes.

For control measures, Pier, et al. (16) recommended

that (a) strict aseptic procedures be maintained in intra-mammary infusion therapy, (b) disposable single-dose applicators be used when infusing antibiotics into the infected udders of several cows, (c) disinfectant solutions be used on the teat ends at the completion of milking, and (d) complete segregation of diseased cows be accomplished in all infected herds.

SURVEY FINDINGS

A questionnaire survey was made in an attempt to obtain information on the national situation in respect to *Nocardia* and *Actinomyces* as causes for mastitis. Questionnaires were sent to public health and mastitis-testing laboratories in the 50 states, Puerto Rico, the Virgin Islands, and to the U. S. Public Health Service Laboratory in Cincinnati.

Fifty-three questionnaires were distributed, and 45 responses were received. Of this number, 28 (62%) of the agencies reported that these organisms had never been found in milk or in mastitis cases, six (13%) reported that no check for these organisms was being made, and 11 (25%) reported the presence of *Nocardia* or *Actinomyces* either in raw milk or in mastitis infections. Most of the positive results were from raw milk sent to the laboratories for mastitis diagnosis. Five (45%) of the positive replies indicated that these organisms were found occasionally (in 10 to 12 samples per year) in whole raw milk, raw cream and raw skim milk received at dairy plants. No incidences were reported in which the organisms were found in pasteurized products.

Five states reported that either *Nocardia* or *Actinomyces* had been involved in mastitis outbreaks. The number of outbreaks which occurred in a given state ranged from one to 15, and the number of animals involved from 20 to 300. The number of cows in certain individual outbreaks was high: in three of the outbreaks reported, the percentage of cases from herds totaling 1000, 400, and 180 cows was 30%, 45%, and 8%, respectively. One laboratory supervisor reported that actinomycotic mastitis had been encountered sporadically in his state for at least 20 years.

SUMMARY

The reported incidence of *Nocardia* and *Actinomyces* in mastitis infections is not alarming when considered in relation to the many other organisms which have been implicated. However, literature indicates that these organisms may be becoming more significant as mastitis causative agents, and that their high virulence causes greater loss of animals than occurs from infection with other organisms usually associated with the disease.

Some health agencies reported having found *Nocardia* or *Actinomyces* in raw milk products or as

causes for mastitis; however, many have not been attempting to relate these organisms to mastitis infections. Perhaps more attention generally should be given to these organisms in determining the cause for mastitis infections and to the possible control steps to be taken. Because of their characteristics, these organisms do not lend themselves to simple control measures. Consequently, this necessitates more alertness on the part of the producer to herd health symptoms, prompt diagnosis, and immediate and perhaps drastic remedial measures.

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