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Katie Portacci
USDA APHIS, CEAH@aphis.usda.gov

Jason Lombard
USDA-APHIS, VS

Mark Schoenbaum
USDA-APHIS, VS

Kathleen Orloski
USDA-APHIS, VS

Mark Camacho
USDA-APHIS, VS

Chapter 22

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Katie Portacci, Jason Lombard, Mark Schoenbaum, Kathleen Orloski, and Mark Camacho

United States Department of Agriculture Animal and Plant Health Inspection Service, Veterinary Services (USDA-APHIS, VS), Colorado

Introduction

The U.S. National Tuberculosis Eradication Program began in 1917 and has made great strides in reducing the prevalence of *M. bovis* in U.S. cattle. Sporadic cases, however, continue to be identified in beef and dairy herds and, more recently, captive cervid herds. The ultimate goal of eradication requires that disease management strategies adapt to changing risks associated with the transmission of *M. bovis*. This chapter describes the low level of BTB occurrence in cattle in the United States.

Finding the source of infection is challenging due to the chronic nature and latent behavior of BTB in cattle and cervids, the performance of live-animal BTB tests in cattle, and the challenges associated with epidemiologic investigations.

From 2001 to 2011, 92 U.S. cattle herds were affected with *M. bovis*. Investigation of these herds revealed several emerging challenges to the goal of BTB eradication in the United States, including changes in management practices, disease emergence in free-ranging white-tailed deer and other cervids, commingling domestic cattle with infected imported animals, and limitations in the ability of tracing animals.

Data in this chapter were collected by state or federal investigators and reported to the U.S. Department of Agriculture (USDA), unless otherwise noted. Most of the data refer to the period January 2001 through December 2011. Some data, however, refer to a respective federal fiscal year—October through September—or to cases that occurred before 2001.

Zoonotic Tuberculosis: Mycobacterium bovis and Other Pathogenic Mycobacteria, Third Edition.
Edited by Charles O. Thoen, James H. Steele, and John B. Kaneene.

Prevalence and distribution of *M. bovis* in U.S. cattle

Slaughter surveillance is the primary method used to identify BTB-infected animals. Live-animal tuberculin skin testing is also conducted for routine purposes such as movement requirements, or as a part of a control program in states where a wildlife reservoir for *M. bovis* has been identified.

Once an infected animal is identified, an attempt is made to trace the animal to its herd of origin and identify all exposed animals (including adjacent herds). The time frame for tracing depends on the availability of records or when the initial exposure of the herd was thought to have occurred.

In 2006, the National Veterinary Services Laboratories began conducting routine spoligotyping on all *M. bovis* cases. The ability to recognize and differentiate unique *M. bovis* strains collected from infected animals provides investigators with another valuable tool for establishing epidemiological relationships between herds.

Summary of slaughter cases, 2001–2011

The United States began to rely primarily on slaughter surveillance in the early 1960s, when the prevalence of infection had become too low to rely solely on live-animal testing. The herd-level sensitivity of BTB slaughter surveillance has been estimated at 50% or less and appears highly variable depending on slaughter plant, herd size, and herd type. To ensure that slaughter surveillance is effective, a minimum standard of five granulomatous lesion submissions per 10,000 adult cattle (sexually intact cattle older than 2 years) slaughtered was established [1]. There is not currently a minimum granuloma submission standard for fed cattle.

The granuloma submission standard serves two purposes: to ensure valid slaughter surveillance and to inform slaughter personnel of expected performance as many common diseases grossly resemble tuberculous granulomas, including actinomycosis, actinobacillosis, coccidioidomycosis, and some carcinomas. Failure to meet the minimum submission standard may allow infected cattle to go undetected and impedes eradication efforts.

During 2005–2011, the annual number of submissions ranged from 8,612 to 13,095 (median, 10,171), resulting in a submission rate of 15.1 to 18.0 per 10,000 adult cattle slaughtered (median, 16.2). From 2001 to 2011, 390 cattle were identified through slaughter surveillance as BTB infected; 42 (10.8%) of these animals were adult cattle; 346 (88.7%) were fed cattle; and 2 (0.5%) were of unknown age. Of the 42 adult cattle infected with BTB, 40 were of U.S. origin and 2 were of Canadian origin. The 40 U.S. origin BTB-infected cattle led to the identification of 22 BTB-affected U.S. herds. Eight of the 40 cattle were untraceable.

Of the 346 fed cattle infected with BTB, 273 originated in Mexico and 2 originated in Canada. Fourteen cases occurred in domestic feeder cattle, ranging from 0 to 3 cases annually. The origin of 57 of the infected fed cattle was classified as unknown, primarily because the animals were sourced from mixed lots consisting of domestic and Mexican-origin cattle, making identification of their origin impossible. Annually, 1 to 20 BTB cases in cattle of unknown origin occurred, with the largest number

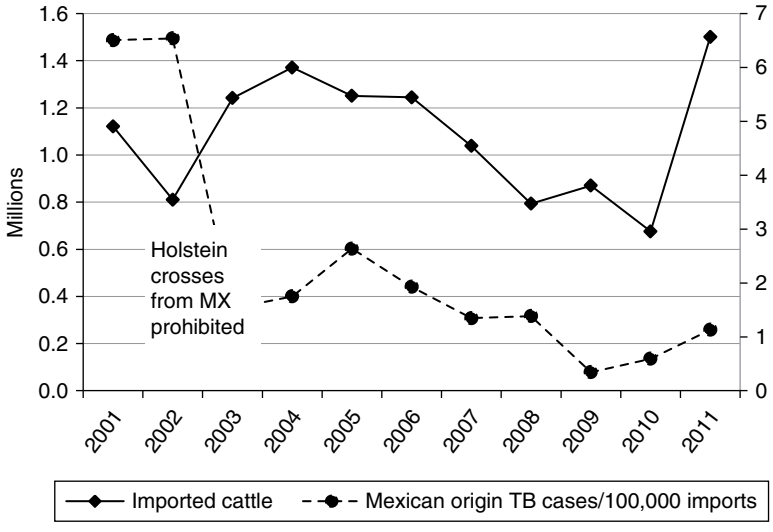

Figure 22.1 Number of Mexican cattle imported annually and confirmed BTB cases per 100,000 imported cattle, 2001–2011. MX = Mexico.

occurring in 2008 as a result of a feedlot outbreak involving retired roping cattle in terminal slaughter channels. Bovine TB cases detected during U.S. slaughter inspection in cattle from Mexico decreased substantially beginning in 2003 to fewer than 2 cases per 100,000 imports and have remained relatively stable since then at 1 to 3 cases per 100,000 imports (Figure 22.1).

M. bovis–affected herds in the United States, 2001–2011

From January 2001 to December 2011, 92 cattle herds in 15 states were declared *M. bovis* affected. Of these, 64 were beef herds, 26 were dairy herds, and 2 were mixed herds (Table 22.1).

In addition to the 22 BTB-affected herds identified by trace investigations associated with infected animals discovered at slaughter, the majority (50) of the affected herds (54.0%) were detected through herd testing conducted in areas associated with BTB infections in free-ranging white-tailed deer in the states of Michigan and Minnesota. Sixteen herds (17.4%) were identified via a trace from another affected herd (excluding Michigan and Minnesota), and the remaining 4 herds (4.3%) were identified through routine testing for herd dispersal sales (2 herds), state entry (1 herd), and by diagnostic testing for clinical disease (1 herd).

National BTB herd prevalence was calculated by dividing the number of affected cattle herds by the number of all cattle herds (beef, dairy, and mixed herds). Similarly, the animal-level prevalence was calculated by dividing the number of infected cattle by the number of all cattle. The herd-level prevalence of BTB in the United States has remained below 0.002% for beef herds and below 0.006% for dairy herds since 2001.

Table 22.1 Number of BTB-affected herds identified per year, by production type (2001–2011).

Production Type	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Beef	10	5	5	0	8	4	6	5	3	13	5	64
Dairy	0	4	5	2	1	2	2	3	2	2	3	26
Mixed	0	1	0	0	0	0	0	1	0	0	0	2
Total	10	10	10	2	9	6	8	9	5	15	8	92

These levels are much lower than the World Organisation for Animal Health (OIE) requirements for freedom from BTB in cattle herds of 0.2%.

Animal-level BTB prevalence has remained below 0.0002% for beef cattle. Prevalence in dairy animals has been more inconsistent, ranging from 0.0001% to 0.0019%. These levels, however, are also much lower than the OIE requirements for freedom from BTB in cattle of 0.1%.

An unweighted within-herd BTB prevalence was estimated based on the data collected from epidemiological investigations of affected herds (2006–2011). The total number of cattle in affected beef herds ranged from 5 to 1,231 head, with an average of 169 head. The total number of cattle in affected dairy herds ranged from 35 to 12,000 head, with an average of 2,680 head.

The number of infected cattle in beef herds ranged from 1 to 27 animals, with a median of 1 and mean of 3. The number of infected cattle found in dairy herds ranged from 1 to 173 animals, with a median of 1 and a mean of 25. The mean within-herd BTB prevalence across all herds was 3.5% (median 1.43%) and ranged from 0.009% to 29.3%. The overall within-herd BTB prevalence in beef herds (4.3%, median 1.72%) was almost triple the within-herd prevalence in dairy herds (1.4%, median 0.17%). The difference might be due to the smaller herd sizes for beef cattle. The mean within-herd BTB prevalence was 9.2% in small beef herds (fewer than 50 head), 4.7% in medium herds (50 to 99 head), and 2.2% in large herds (100 or more head). The mean within-herd BTB prevalence was 1.4% in small dairy herds (fewer than 100 head), 3.8% in medium herds (100 to 499 head), and 0.5% in large herds (500 or more head). There were significant differences in within-herd BTB prevalence by herd size for both beef and dairy herds.

Categories of affected herds

Affected herds associated with white-tailed deer

Both Michigan and Minnesota have experienced shared infection in free-ranging white tailed deer and cattle. More information on these strains can be found in Chapter 23.

Captive-cervid-associated affected herds

One unique strain of *M. bovis* has been identified in captive elk, free-ranging elk, and cattle. This strain of *M. bovis* was found in both recent and archived samples from as early

as 1991. The outbreak in the 1990s was extensive and involved more than one strain, but this discussion is limited to a strain that has also been found recently in affected cattle herds. Generally referred to as the elk strain or captive cervid strain of BTB, this strain has been identified in eight captive cervid herds and six cattle herds in eight different states from 1991 to 2011. More on this strain can be found in Chapter 23.

Affected dairy herds

Since 2001, 26 U.S. dairy herds have been affected with BTB; 17 of these herds were located in the western half of the United States. Affected herds were found in several states: Arizona (1 herd), California (10 herds), Colorado (1 herd), Michigan (8 herds), New Mexico (3 herds), Ohio (1 herd), and Texas (2 herds).

Of the 26 affected dairy herds, 2 had a relatively large number of BTB-infected cattle. One of the two had been tested the year prior to detection as part of routine Pasteurized Milk Ordinance testing. During the testing, two cows were classified as suspects, but infection could not be confirmed. After identification of the infected cow at slaughter, a very high within-herd prevalence was found (11.1%). In addition, 16 calves that had been sold at 1 to 3 days of age were traced and found to be infected with BTB, the youngest being 4 months of age. These calves led to the discovery of five more BTB-affected herds. All affected herds were depopulated.

The second herd was also detected via slaughter surveillance but had no recent history of testing. The herd did have a trace-back from slaughter surveillance in the 1980s, but testing, including the removal and necropsy of approximately 20 cows, revealed no additional infection at that time. Unfortunately, no information on strain type was available from the 1980s case. In the current case, most of the more than 50 BTB-infected cows were in the dry period during the same 2-month window, suggesting that the cows were exposed during this period, most likely by a cow shedding large amounts of *M. bovis*. Two infected yearling heifer calves from the infected cows were also found to be infected, as well as another yearling whose dam was culled before the herd was identified as affected. Although a large number of cattle were infected, the most likely exposure period occurred only 10 to 11 months before the first case was detected. This herd was depopulated.

For the majority of dairy herds, the source of BTB introduction was not identified. There has been speculation that dairy workers have transmitted BTB to cattle, and although several references in the literature suggest this possibility [2–4], it is very difficult to prove. Many of the affected dairies had added cattle or were exposed to other high-risk cattle (e.g., Mexican-origin, such as roping steers) prior to detection.

Of particular interest is the variety of BTB strains identified in the western United States. For example, the two strains found in the high-prevalence BTB herds mentioned previously had never before been found in U.S. cattle. When multiple herds are affected with the same strain of BTB, which occurs infrequently, the epidemiologic link almost always involves cattle movement between the affected herds. In contrast, the strain found in Michigan dairy herds is the same strain found in all Michigan cattle cases and in Michigan deer.

The potential of BTB being transmitted at off-site heifer growing facilities—where a large number of cattle from multiple owners are commingled—has been considered for a

number of years. To date, there has been only one incident in which an operation was the focus of an epidemiological investigation. This particular operation raised thousands of calves supplied by about 100 different sources and sold cattle to multiple states. This operation was not confirmed as the source of BTB.

Bovine TB infection in dairy herds continues to be a problem in the United States. Although most of the 26 BTB-affected herds had few infected animals, 2 had a relatively large percentage of infected animals, the reason for which has not been determined. The BTB strains found in the higher prevalence herds might have been more contagious or the cattle in the herds might have been more susceptible to the disease. Ultimately, the source of BTB in affected herds must be determined in order to institute preventive practices that reduce the risk of disease introduction.

Sporadic beef cases

Since 2001, 10 BTB-infected adult beef cows have been detected at slaughter. One case occurred in 2001, while the remaining cases occurred from 2005 to 2011. These animals were from South Dakota (4 cows), Nebraska (4 cows), North Dakota (1 cows), and Oklahoma (1 cow). For 2 cases, *M. bovis* was confirmed in the animals' herd of origin (Nebraska and Oklahoma), but the source of infection was not determined for the remaining 8 cases. Laboratory results indicate infections with six different strains of *M. bovis*. The untraceable beef cow in the 2001 case had the same *M. bovis* isolates as the affected beef and captive cervid herds identified from South Dakota in 2009.

Roping steers and rodeo event cattle

From 2001 to 2011, 30 cases of BTB were associated with rodeo event cattle. One case with widespread impact began in 2011 with a Corriente breed steer imported from Mexico. The cattle were sorted at the border and sent to various locations, including a roping-steer operation in Arizona. The Corriente steer was tested in Arizona according to interstate movement requirements within 60 days of importation and identified as BTB infected. State and federal regulatory officials traced the cattle that might have had contact with this steer to 10 other states.

Another case of BTB in a roping steer occurred in Mississippi in 2010. A retired roping steer was detected through slaughter surveillance, and through herd testing a BTB-infected adult beef cow was identified. The herd was depopulated. In 2007, a BTB-infected rodeo bucking bull was found by slaughter surveillance though BTB could not be confirmed in the herd of origin. A second infected bucking bull in a different herd in which the index case had previously resided was identified through the subsequent investigation and the herd was depopulated. Both bulls had traveled frequently, resulting in an extensive investigation.

In 2008, an outbreak of BTB occurred in a group of retired roping steers in a feedlot, resulting in the detection of 21 infected animals. As a result, 591 heifers and 38 adult cattle in nonslaughter feedlot channels were traced and tested. Other cattle exposed to the steers while they were in market channels before entering the feedlot were also tested.

A Mexican-origin roping steer imported in 2004 was confirmed as BTB infected when it was slaughtered in 2006. This steer resided on premises with domestic beef breeding cattle. While *M. bovis* was not detected in this cattle herd, it was depopulated because of the exposure risk.

Event cattle may present a higher risk of transmitting BTB than cattle in feeding channels because event cattle are often imported from Mexico, frequently move to events in different states, and have increased contact with rodeo stock and other domestic cattle. Additionally, Mexican-origin roping cattle infected with BTB are in the United States substantially longer than Mexican feeder cattle (median 24 and 10 months, respectively).

Summary

The U.S. beef and dairy cattle industries are large and complex. There are about 30 million head of beef cattle and 9 million head of dairy cattle in the United States, and some of these animals are moved or commingled along the production chain. Commingling and/or exposure to infected cattle or wildlife are primary practices implicated in the transmission of BTB [5,6]. Of particular importance is the exposure of breeding cattle to high-risk animals such as feeder cattle, rodeo stock, and roping steers, especially if any of the animals are of Mexican origin.

Although the number of BTB-infected cattle imported from Mexico (and number of associated cases identified) has been declining since the late 1990s, Mexican-origin cattle still present a risk to U.S. cattle. About 80% of BTB-infected animals detected at slaughter from 2001 to 2011 were cattle of Mexican origin. Cattle used for rodeo events, including team roping, are commonly imported from Mexico and some cattle operations have Mexican-origin roping cattle in contact with the breeding herd. Other operations may graze Mexican-origin cattle as a cost-effective method of weight gain. Cattle on 1% of U.S. beef cow-calf operations were commingled or had fence-line contact with cattle of Mexican origin, but no cattle on operations that specialize in raising dairy heifers had contact with Mexican-origin cattle according to one USDA study. Investigations of BTB-affected cattle herds have also documented the commingling (e.g., on feedlots and during grazing) of domestic cattle with cattle from Mexico and the occurrence of fence-line contact between imported Mexican cattle and domestic breeding herds.

In areas where a wildlife reservoir of BTB exists, for example, white-tailed deer in Michigan, contact between wildlife and cattle and/or their feed presents a risk for BTB transmission. Disease transmission can also occur between dairy and beef operations when beef operations use suckling calves from dairies to nurse beef cows that have lost their calves.

Purchasing or leasing cattle can also increase an operation's risk of acquiring BTB. During a 12-month period, approximately one-third of U.S. dairy and beef cow-calf operations brought on any cattle. Bred dairy heifers, lactating dairy cows, or weaned dairy bulls were brought on by approximately 13% of U.S. dairy operations. Weaned beef bulls were brought on by approximately 20% of U.S. beef cow-calf operations. Only 13.8% of dairy operations and 5.4% of cow-calf operations tested new additions for BTB.

Operations in which cattle have had contact with cattle from other operations are also at a higher risk of BTB infection. These contacts can occur at off-site heifer-raising facilities, community grazing, rodeos, and shows.

The commingling of cattle on heifer-raising operations and at events such as rodeos are other areas of concern. About 10% of U.S. dairy operations raised heifers off-site, and two-thirds of these operations sent heifers to a facility in which cattle had contact with cattle from other operations. Only 5.4% of U.S. cow-calf operations had any cattle return after leaving the operation (excluding grazing) to attend an event. The percentage of dairy operations that had any cattle return after leaving the operation for an event is not available.

Another practice that increases the potential for BTB introduction is feeding calves unpasteurized milk from other operations. This practice is most likely to occur on operations that raise preweaned calves for multiple dairies, such as heifer-raising operations. In 2011, a study of heifer-raising operations revealed that 1 of 10 operations and 1 of 12 dairy heifers were fed unpasteurized waste milk at these operations.

The potential of BTB transmission from humans to cattle has been reported in the literature [2–4], but frequently the transmission involved *M. tuberculosis*, rather than *M. bovis*. Human-to-cattle spread of *M. bovis* is more likely to occur on dairy operations in which human/animal contact is frequent and a large part of the workforce is Hispanic [7–9]. In one study of 165 human *M. bovis* cases from 1995 to 2005, Hispanics, relative to non-Hispanics, had 10 times the odds of having *M. bovis* than *M. tuberculosis* [10]. Humans with *M. bovis* were at almost 11 times the odds of having extrapulmonary disease compared with human cases of *M. tuberculosis*. Genitourinary tuberculosis is one form of extrapulmonary disease, and excretion of *M. tuberculosis* in the urine was reported in 80% of cases [11]. *M. bovis* is a significant re-emerging cause of extra pulmonary BTB in Mexico. Consumption of unpasteurized dairy products is the most likely mode of transmission [12].

While cattle movement remains an important risk factor for *M. bovis* introduction, other risk factors have emerged in recent years. Understanding the role of these risk factors through epidemiologic investigations is important in reaching the ultimate goal of eradication. Slaughter surveillance has enhanced the ability to find infected animals, and tools such as the use of molecular epidemiology have helped investigators identify relationships that would not be apparent otherwise. Limitations in traceability and individual-animal identification, along with the inherent nature of bovine TB, continue to hinder investigations.

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