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The Epidemiology of Tuberculosis in Cattle in the Republic of Ireland: Observations in the Role of Cattle-to-Cattle Transmission of *Mycobacterium bovis*

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Abstract

Bovine tuberculosis eradication programmes, based on the identification of infected cattle, by means of the tuberculin test, and their removal before they became infectious, have succeeded in eradicating the disease in many countries. However, there has been little discernible improvement in bovine tuberculosis levels in the Republic of Ireland since 1965 in spite of the implementation of an intensive eradication programme.

The main route of *M. bovis* infection for cattle is the aerogenous one with the oral route being of lesser importance. There is some variation in the reported minimum dose required to set up infection in cattle by the respiratory route.

Cattle-to-cattle transmission trials and field studies of tuberculosis outbreaks showed that the majority of in-contact cattle did not display evidence of infection, based on tuberculin test results and post-mortem examination. Furthermore, the rate of transmission of *M. bovis* from animals which were infectious was low. This suggests that cattle in the early stages of disease do not commonly transmit *M. bovis* to in-contact animals.

On the basis of the scientific evidence currently available and the progress of the National Eradication Programme in the Republic of Ireland to date, it would appear that, bovine to bovine transmission of *M. bovis* is no longer the primary source of new outbreaks here.

Effective means of addressing the other factors involved in the transmission of tuberculosis will be required to achieve the final eradication of the disease in the Republic of Ireland.

Introduction

A national tuberculosis eradication programme began in the Republic of Ireland in 1954, based on a "test and slaughter policy" using the single intradermal comparative tuberculin test as the principal method of diagnosis. Rapid progress was made between 1954 and 1965 but this progress was not maintained. Approximately 30,000 tuberculin test reactor animals were removed annually between 1968 and 1988. In the period 1988 and 1990, 44 million tuberculin tests were carried out on the seven million cattle that make up the national herd (Downey, 1992).

This exhaustive testing programme was accompanied by a variety of other measures aimed at preventing cattle to cattle transmission. Following the introduction of these new measures, the total number of tuberculin reactors removed in 1989 and 1990 increased to over 40,000 animals. However, there was no discernible improvement in the prevailing disease levels subsequently (Downey, 1992).

The failure of the eradication programme to reduce the apparent prevalence of tuberculosis in the period since 1965 merits a detailed examination of the relative importance of all sources of *M. bovis* infection for cattle in clear herds, including

that of *M. bovis* infected cattle in contiguous herds and infected purchased cattle.

Route of infection and the infective dose for cattle

Tuberculosis in cattle is mainly a pulmonary disease. The principal route of infection for cattle is the respiratory route and the main mode of transmission between cattle is by aerosol spread.

The infective dose for cattle (i.e., the minimum number of tubercle bacilli that is needed to establish an infection) is much lower for the respiratory route than the oral route (Weber and Titze, 1910). There is some variation in the reported minimum dose required to set up infection by the respiratory route. This is an important factor in the transmission process from cattle to cattle because it influences the likelihood of an infected animal transmitting *M. bovis* to other cattle during the various sequential and pathological phases of the disease

The size of the droplets carrying the mycobacteria in the respiratory tract, and the ability of these particles to reach the alveoli may determine infectivity, rather than the number of organisms to which an animal was exposed (Wells *et al.,* 1948). Analysis of the outbreaks of tuberculosis in cattle herds in the course of the tuberculosis eradication programme in the Republic of Ireland shows 49% of some 18,607 herd breakdowns recorded in eleven counties from 1982 to 1989 inclusive consisted of a single reactor animal (Anon., 1990). These data suggest that a considerable number of infected cattle did not transmit *M. bovis* to other herd members in the period prior to their removal.

Cattle-to-cattle transmission experiments

Cattle to cattle transmission experiments suggest that cattle can remain free of tuberculosis when they are in-contact with tuberculous cattle over prolonged periods.

O'Reilly and Costello (1988) described an experiment in which 22 naturally sensitised tuberculin test positive cattle were housed and/or grazed with 32 non-infected cattle. All animals were tuberculin-tested at regular intervals and subjected to a detailed post-mortem examination at the end of the experiment. There was no evidence of infection in any of the 32 in-contact animals, either by means of the tuberculin test or at post-mortem examination. In a more recent experiment in 1991 undertaken by Costello and Doherty, two tuberculin test reactors were housed with one in-contact animal in each of ten loose houses for a period of 12 months (M.L. Doherty, personal communication). One of the in-contact animals had gross lesions at post-mortem examination. *M. bovis* was isolated from the lymph nodes of this animal and from three other in-contact animals following slaughter. Two of these four animals were inconclusive to the standard interpretation of the single intradermal comparative tuberculin test conducted just prior to slaughter.

Studies which were undertaken in other species may be pertinent to transmission between cattle. In both badgers and man, infectivity of *M. bovis* for "in contacts" has been associated with (i) clinical disease and (ii) the excretion of large numbers of tubercle bacilli. Following a study of the immune response in badgers experimentally infected with *M. bovis*, Mahmood *et al.* (1987) concluded that badgers are only likely to be infectious for other badgers and a potential danger to cattle in the late stages of the disease.

Investigations of human cases in the Netherlands showed that tuberculous patients with direct smear-positive sputum

samples infected 20.2% of home contacts, whereas those patients with direct smear negative, culture positive or negative sputa only infected 1.1% of family contacts (Rouillon *et al.,* 1976). Bates (1980) concluded that patients with a vigorous cough of several months duration whose sputum contained large number of bacilli were highly likely to infect a high percentage of their contacts.

Cattle to cattle transmission within M. bovis infected herds

Schoenbaum *et al.* (1992) reported on an investigation of an epidemic of bovine tuberculosis originating from an infected beef herd in Oklahoma, USA. All 59 cows and 37 calves were dispersed from this herd following a sale in September and October, 1988. In August, 1989, one of these animals was found to have generalised tuberculosis at post-mortem examination. Tracing of the other animals from the sale was then undertaken. Thirty one of the 59 adult cattle were located and slaughtered. In a personal communication, Dr. Schoenbaum confirmed that 12 (39%) of the 31 adult cattle located had tuberculous lesions at post-mortem examination. The 12 infected animals had passed through a total of 13 herds and had likely been in contact with up to 2,438 other cattle in these herds. These herds were depopulated. A further 1,969 exposed animals which had been sold from these herds prior to the initiation of the investigation were traced to 74 additional herds and all of these animals were slaughtered. Five of the in-contact animals were positive on tuberculin testing; necropsy examination identified a further seven tuberculous animals among the depopulated group, giving a total of 12 infected animals and a prevalence of 0.3% among the exposed animals.

There has been a considerable increase in the level of importation to the USA of Mexican steers for fattening in feedlots since 1982. Over one million such steers were imported in 1991. A report prepared by the United States Department of Agriculture on the epidemiology of tuberculosis in the United States stated that the number of confirmed *M. bovis* cases in steers of Mexican origin per million steers slaughtered increased from three to 25 from 1988 to 1991 (Anon., 1992). A corresponding upward trend in the rate of *M. bovis* in non-Mexican cattle was not found. It was concluded that it was unlikely that steers of Mexican origin were serving as a source of infection for domestic steers. However, caution is required in relation to these findings because the data available to assist in the evaluation of the risk of *M. bovis* to domestic cattle by imported steers were incomplete.

Epidemiological evidence indicated that the tuberculin testing regime adopted in Great Britain ensured that virtually all tuberculous cattle were detected and slaughtered at an early stage of the disease before they became infectious. Wilesmith and Williams (1986) stated that there was a low frequency of contiguous herd spread in Great Britain. This was consistent with the findings within infected herds which indicated a low or zero rate of within-herd transmission in the majority of restricted herds. The majority of herd breakdowns were associated with the presence of infected badgers in the vicinity.

In a review of the epidemiological and pathological evidence, Dunnet *et al.* (1986) considered that with regular tuberculin testing, it was far less likely that cases of tuberculosis in cattle would progress to the point where animals were actively excreting significant numbers of *M. bovis* before the infection was detected. By far the majority of tuberculin reactor cattle were found on post-mortem examination to be infected but not infectious, i.e. liable to pass the infection to other animals. The authors

concluded that cattle to cattle transmission had not been a major factor in the transmission of disease between herds in Great Britain in recent years.

Commenting on the Northern Ireland data, Dunnet *et al.* (1986) observed that, on the basis of the findings presented, transmission of *M. bovis* from one infected animal to other cattle may be more frequent than was currently recognised. However, the results of "check-testing" herds contiguous to breakdowns indicated that *M. bovis* was rarely transmitted to neighbouring herds. The Northern Ireland findings seemed likely to be significant only in the context of transmission between animals within a herd.

A study of 175 herd breakdowns in county Cavan in the Republic of Ireland during 1989, indicated that there was little evidence of transmission of disease to homebred animals from infected purchased animals (Griffin, 1993). Only three additional standard reactors were found among the homebred cattle in 12 breakdowns, in each of which there was strong evidence that the source of the breakdown was purchased cattle.

In herd breakdowns in Great Britain which were attributed to imported Irish cattle, it was found that the breakdown cleared up very quickly following the identification and removal of the reactor animals (Wilesmith, 1983). Overall, 175 incidents were attributed to contact with cattle purchased from Irish herds between 1972 and 1978, but only eight herds suffered incidents in more than one calendar year.

Frequency of breakdowns attributed to purchased cattle

Cattle movement in Ireland is subject to strict controls. All animals are identified individually by means of an official ear tag and an identity card accompanies each animal throughout its life. This card contains details of tuberculin tests carried out on the animal and details of movement of the animal through marts, thus allowing the tracing of animals from herd to herd. All cattle must have passed a tuberculin test within 60 days prior to sale.

An analysis of reports on 504 herd breakdowns for which field investigations were completed between August 1990 and the end of 1991 revealed that 7% of the breakdowns were considered likely to be attributable to purchased cattle (Griffin, 1992). The comparable figure for the analysis of 3,975 herd breakdowns which occurred between 1987 and 1990 was 11% (Griffin and Hahesy, 1992). In both of these studies, the herds were not chosen at random, however the breakdowns reported were selected for investigation by Veterinary Inspectors mainly on the basis of their relative importance and consisted mainly of larger breakdowns.

In a case control study of herds which failed the six-month check test, it was found that herds which purchased cattle between the clearance test and the six-month check test were twice as likely to fail the six-month check test than herds which did not purchase animals (Christiansen *et al.*, 1992).

Transmission of *M. bovis* between neighbouring herds

An analysis of epidemiological reports field investigations of 504 breakdowns were completed between August, 1990 and the end of 1991 indicated that 23% were attributable to lateral spread, i.e., transmission of *M. bovis* between cattle in neighbouring herds (Griffin, 1992).

While field investigations are a valuable source of information and provide the principal means of identifying sources of individual breakdowns, such findings must

be treated with caution because it may be difficult to distinguish between different possible sources. In particular, there can be a difficulty in differentiating between breakdowns due to lateral spread from infected cattle in contiguous herds and those attributable to infected badgers and other wildlife in the district.

Discussion

Since the late 1980's renewed attention has been given to the role of infected cattle in the epidemiology of tuberculosis in that species. There is general agreement that the main route of infection for cattle is and has always been the aerogenous one, with the oral route being of lesser importance. Francis (1947) concluded that, under most conditions, infection acquired *via* the respiratory route was responsible for 80 to 90% of cases in cattle.

One area of contention concerning cattle to cattle transmission is in relation to the stage at which the infected animal becomes infectious. On balance, the evidence available at present suggests that, while some animals in the early stages of disease do excrete *M. bovis,* in-contact animals do not readily acquire infection. The outcomes of bovine tuberculosis eradication programmes world-wide suggest that excretion by cattle in the early stage of disease is not a major obstacle to the eradication of tuberculosis in that species. While Great Britain was declared attested in 1960, the disease has since proved to be intractable in the south west of England. In certain areas, where the reactor incidence was high, the frequency of testing was increased to three-monthly intervals. This measure failed to resolve the problem. It was found, subsequently, that infected badgers were the main reservoir of disease in the area. As a result, herds in the south-west were tested once every two years, or annually where breakdowns occurred more frequently (Dunnet *et al.* 1986).

In conclusion, studies undertaken to-date indicate that infected cattle can excrete *M. bovis* at various stages following infection, but it is the number of *M. bovis* organisms excreted and/or the size of the particles carrying these organisms which may be the crucial factor(s) in setting up infection in in-contact cattle, either in that herd or in an adjoining herd. It would appear that bovine to bovine transmission of *M. bovis* is no longer the primary source of new outbreaks here. Effective means of addressing the other factors involved in the transmission of tuberculosis will be required to achieve the final eradication of the disease in cattle in the Republic of Ireland.

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