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<td><strong>Authors(s)</strong></td>
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<tr>
<td><strong>Publication date</strong></td>
<td>1995-07</td>
</tr>
<tr>
<td><strong>Series</strong></td>
<td>Selected Papers, 1994</td>
</tr>
<tr>
<td><strong>Publisher</strong></td>
<td>University College Dublin. Centre for Veterinary Epidemiology and Risk Analysis</td>
</tr>
<tr>
<td><strong>Item record/more information</strong></td>
<td><a href="http://hdl.handle.net/10197/8951">http://hdl.handle.net/10197/8951</a></td>
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Factors Relevant to the Investigation of Outbreaks of *Mycobacterium bovis* Infection in Cattle

J. D. Collins

Introduction

In Ireland, as in other developed countries to-day, tuberculosis rarely affects cattle to the extent of causing clinical signs, as was the case in the 1950's when the Bovine Tuberculosis Eradication Scheme was first introduced. Rather, the majority of affected cattle now disclosed by the national programme of bovine tuberculosis eradication are found to be in the early stages of the disease and, at *post-mortem* examination, most cases show only local involvement of the regional lymph nodes of the head and thorax. That is, the majority of infected cattle are identified before they become persistent excreters of *Mycobacterium bovis*, and before the disease has advanced to the stages commonly seen forty or more years ago.

The cases of advanced tuberculosis which are encountered serve to remind one of the progressive nature of this disease and of the extent to which animals so affected may infect other cattle and contaminate their own environment if they go undetected. On the other hand, the rarity of such cases is one of the visible benefits of the national tuberculosis eradication programme and shows that, provided prompt corrective action is taken at herd level, the problem of tuberculosis in cattle, with few exceptions, is amenable to control. This is evidenced by the fact that over the past forty years there has been a progressive reduction in the extent of tuberculosis seen in cattle at slaughter (Table 1). Furthermore, in 1994, "singletons" accounted for some 48% of all herd restrictions.

The Tuberculosis Investigation Unit conducts studies on the factors that militate against the eradication of tuberculosis in cattle at the national and regional levels. The Unit operates in close collaboration with the District Veterinary Offices, the Veterinary Research Laboratory, the Regional Veterinary Laboratories, Food and Agricultural Development Authority (Teagasc) staff, and with ERAD, the Animal Disease Eradication Board.

The Unit has direct access to computerised records on all herds, including individual animal histories, since 1987. Protocols for the interrogation and analysis of these data have been developed which allow the integration of tuberculin test details, field investigations and meat plant findings, using the EpInfo programmes. Geographic Information Systems (GIS) are employed to define the spatial and temporal distribution of herd outbreaks and the characterisation of wildlife habitats. Its work to-date has highlighted the benefits of a multidisciplinary approach to the investigation of tuberculosis in cattle and other animals.

Factors Which Militate Against Eradication

The factors which are of importance to the successful control and eventual eradication of *M. bovis* on Irish farms are discussed under four headings, namely, animal production practices, the biological limitations of the tuberculin test, changes in the form of presentation of tuberculosis in cattle and the implication of free living...
animal species in the transmission of *M. bovis* to cattle.

1. Animal Production Practices
Any animal disease eradication programme, if it is to be successful, must take into account normal practices of production and trade. In the Republic of Ireland, cattle production is comprised of three phases, viz. calving, rearing and fattening. This pattern results in the movement of young calves out of the southern dairying areas in the spring to the west and midlands, and the movement of store cattle to the midlands and eastern counties for fattening and finishing in the autumn. Beef production is based on grass production with the cattle being kept outdoors on grass from mid-March to October each year. On average, beef animals pass through three or more different holdings before they are slaughtered at 28 - 30 months of age.

The dairy herd is a more stable entity as regards animal movement, although in recent years there has been a considerable increase in the size of individual herds and a decrease in herd numbers. Along with the greater risk of within-herd spread of infection in the larger herds, there is the added complication that increased herd size may have an adverse effect on the specificity of the tuberculin test, on statistical grounds alone (Martin *et al.*, 1992; O'Keeffe, 1993).

During the past thirty years there has been a trend towards winter housing based on slatted floored units, and cubicles. As a result, slurry rather than farmyard manure now comprises the major part of animal effluents on both beef and dairy enterprises. Manure, when properly composted, presents little risk for cattle so far as *M. bovis* infection is concerned; on the other hand, the management of contaminated cattle slurry on restricted farms is a significant factor in determining the duration of the outbreak and the likelihood of further breakdowns on the restricted farm, as well as on nearby holdings (Collins, 1981; Christiansen *et al.*, 1993 and Griffin, 1993).

The influence, if any, of other factors such as the seasonal calving pattern in dairy herds on the accuracy of the tuberculin test when conducted on periparturient cows, or the use of therapeutic substances that have an immuno-modulating effect in this regard, have not yet been quantified under Irish conditions. Such medication, together with extensive animal movement, changes in farm management practices, enterprise type and herd composition, along with increases in herd size, are now an inherent part of Irish agriculture. These factors can be expected to have a bearing on the rate of progress achieved in the tuberculosis eradication programme.

2. The Biological Limitations of the Tuberculin Test
The tuberculin test as used in cattle has recently been reviewed by Monaghan and others (1994). As a screening test intended for field use, this test, when applied as the single intradermal comparative tuberculin test (S.I.C.T.T.), has proved to be just as successful in Ireland as in eradication programmes conducted in other countries including Great Britain. In the present context, however, it is of the utmost importance to realise that the definitions of the terms, "tuberculin test" and "tuberculin reactor", have varied over time. The frequency of tuberculin testing along with the degree of severity of interpretation of the test results have not been constant throughout the scheme. This variation in the pattern of tuberculin testing, along with changes in the types of tuberculins employed, are likely to have had a direct effect on the apparent incidence and prevalence of the disease, as measured solely by the numbers of animals removed as tuberculin reactors each year.
3. Changes in the Form of Presentation of M. bovis Infection in Cattle

The development of lesions of tuberculosis discernible at post-mortem examination is a consequence of tissue invasion and, as such, represents the later stages of the disease process, rather than the infective process. Tuberculous lesions, therefore, may not be a feature of tuberculosis in all cattle infected with M. bovis. If present, they may not be demonstrable, using the current methods of diagnosis, in all infected cattle including those removed as reactors to the tuberculin test. The pathological changes which are identified are often confined to a localised lesion in a lung and/or a lymph node which receive lymph from an infected portal of entry such as the respiratory or digestive tract. This has a bearing on the efficiency of diagnosis or confirmation of the condition in tuberculin-reactor cattle since up to 53% of lesions may go undetected at this stage (Corner, 1994).

Accordingly, when the results of screening and diagnostic tests are being evaluated due account requires to be taken of the relatively low sensitivity of routine post-mortem examination, as conducted under commercial conditions. Otherwise the tests in question may be seriously undervalued. For this reason, the use of the term, “likely to be infected with M. bovis”, rather than “tuberculosis”, should be considered, in the context of post-mortem findings relating to tuberculin reactor cattle.

In effect, "the gold standard" for tuberculosis in cattle is less than optimal and this fact is a serious impediment to the satisfactory evaluation of diagnostic tests including the tuberculin test.

4. The Implication of Free Living Animal Species in the Transmission of M. bovis to Cattle

According to Collins and Grange (1983), "it is axiomatic that no control measures against transmissible diseases can be totally effective unless all reservoirs of the causative agent can be eliminated". Hence, reliance upon the results of the tuberculin test, or on other immunological tests, to the exclusion of the epidemiological data resulting from field investigations and analysis of the history of the herds in question, can lead to a false sense of security in local situations where non-bovine sources of M. bovis co-exist with the cattle population. The tuberculin test, in its various forms, has performed well as a mass screening test in cattle, but can provide only retrospective evidence of exposure to infection. However, the occurrence of another animal host of M. bovis on the farm which is capable of transmitting infection to the herd represents a threat to the otherwise unexposed herd which cannot be countered by the use of the tuberculin test alone.

Badgers (Meles meles) and deer are prone to infection with M. bovis and each can serve both as a reservoir host and as an active disseminator of the tubercle bacillus. The potential for cross infection within and between each of these three animal species under Irish conditions is high, given the degree of direct and indirect contact that occurs at local level. The likelihood of badger involvement in the introduction of M. bovis infection into otherwise unexposed cattle populations is considerable (O'Connor and O'Malley, 1989; Dolan, 1994). The isolation of M. bovis having the same restriction endonuclease analysis (REA) characteristics in both badgers and cattle in the course of the same outbreak provides further evidence of the close association that exists in nature between these two animal species (Collins et al., 1994).

In a detailed analysis of epidemiological reports on 504 herd outbreaks, Griffin (1993) found evidence of badger involvement in 14 per cent of cases. Lateral spread from contiguous farms was adjudged
to have been responsible for a further 23 per cent of the outbreaks. It is reasonable to consider that infected badgers associated with the farm under restriction and its contiguous farms, may have been responsible for a proportion of the latter outbreaks, in addition to those resulting from direct cattle-to-cattle contact between herds.

Conclusions
The progressive eradication of tuberculosis in cattle in the Republic of Ireland will be dependent upon a sustained effort by all concerned parties to maintain the accredited status of the vast majority of herds in the State. At present this is being achieved through (i) the annual surveillance testing programme, and other monitoring procedures, (ii) the segregation of these herds from all known infected herds until such time as these latter herds can confidently be declared to be free of tuberculosis, and (iii) the encouragement of farmers to practise sound husbandry methods in the care of their herds. However, the emergence of a considerable wildlife reservoir of *M. bovis* infection is proving to be a serious obstacle to eradication, at the national level, in the final stages of the scheme.

Because of the varied nature of the immune response of cattle to infection with *M. bovis* and the fact that *M. bovis*-infected cattle are now being recognised at a much earlier stage of the disease than formerly, some difficulties in diagnosis can be expected to arise both with field, as well as laboratory-based, tests. These can best be dealt with by (a) identifying the herd rather than the individual animal as being the target population at risk, and (b) using more than one diagnostic procedure, to arrive at what is in fact a disease management decision regarding the best option for action. The prevention and, where necessary, the management, of tuberculosis at farm level requires to be given appropriate attention, both by the farmer and by his/her advisers, as a basic component of any herd health programme.

The need to devise and implement an effective scheme for the control of tuberculosis in free living animals with which the cattle population may come in contact, or a means of reducing or eliminating such contact, is now recognised. The development of a vaccine for use in the badger is currently under review (Report, 1994; WHO/FAO/OIE Report, 1995). Such measures are necessary in order to ensure the protection of the national herd, which has already been the subject of considerable exchequer expenditure in order to ensure its protection from infection from infected cattle.

References
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Report (1994). Report of a steering committee the feasibility of developing a vaccine against tuberculosis for use in the badger (*Meles meles*). Department of Agriculture, Food and Forestry, Dublin and Department of Agriculture for Northern Ireland, Belfast, Northern Ireland.

Cattle.

<table>
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<th>Period</th>
<th>% carcases totally condemned</th>
<th>% carcases partly condemned</th>
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<td></td>
<td>Cows</td>
<td>Steers</td>
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<tr>
<td>1950 - 1954</td>
<td>2.32</td>
<td>0.25</td>
</tr>
<tr>
<td>1960 - 1964</td>
<td>1.71</td>
<td>0.37</td>
</tr>
<tr>
<td>1970 - 1974</td>
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<td>0.01</td>
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<td>1980 - 1984</td>
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<td>0.01</td>
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<tr>
<td>1990 - 1994 *</td>
<td>0.01</td>
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* provisional figures

Source: Division of Veterinary Services, Dept. of Agriculture, Food & Forestry, Dublin.