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Meat Plant Surveillance and its Role in the Eradication of Tuberculosis in Cattle

J. D. Collins

Introduction
The impetus for the eradication of tuberculosis from national herds in the developed countries originated from concerns for public health and was later accelerated by trade demands for disease-free animals. The rate of condemnation of carcasses of both attested cattle and reactor animals at post-mortem examination was used, and continues to be used, as a measure of the prevalence of tuberculosis in national herds, or of the progress of bovine tuberculosis eradication programmes. In the developing countries which do not have such a programme in place, meat plant surveillance based on gross examination may be the principal if not the only means available for assessing the tuberculosis status of the national herd.

Detection of gross lesions of tuberculosis in slaughter cattle
The detection of suspect lesions of tuberculosis in cattle slaughtered under commercial conditions is subject to constraints relating to, inter alia, line speed, inspection facilities (e.g. lighting, space, time), examination technique and the ability of the veterinary inspector to recognise pathological evidence of tuberculosis in the organs and tissues under examination. One of the beneficial effects of national bovine tuberculosis eradication programmes has been the effective removal of most infected cattle before they reach the clinical stages of the disease and before the major organs show overt signs of involvement. Consequently the detection of lesions of tuberculosis is more difficult than formerly because lesions are likely to be more discrete and fewer in number.

Corner et al. (1990) found that the detailed examination of three pairs of lymph nodes associated with the respiratory tract, viz. mediastinal, retropharyngeal and bronchial lymph nodes, led to the detection of tuberculous lesions in 76% of 245 cattle which were found to have only a single lesion at slaughter. In a further 9.8% of these cattle the sole lesion was found in the substance of the lung, indicating the importance of palpation of this organ in the course of routine inspection. Furthermore, examination of two additional sets of lymph nodes which are routinely examined at slaughter, viz. the parotid and mesenteric lymph nodes, led to the detection of tuberculous lesions in a further 5.3% while the examination of two sets of carcase lymph nodes, viz. the iliac group and the prescapular lymph nodes, disclosed lesions in an additional 4.0% of these animals.

Disclosure of tuberculous lesions in tuberculin-reactors at slaughter
On the other hand, the use of cytokine assays in parallel with the tuberculin test (Figure 1) has identified M. bovis-infected cattle in known-infected populations that had not been detected by the latter test alone (Whipple et al., 1996; Monaghan et al., 1997). This shortfall has implications for

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the overall efficiency of national surveillance programmes, particularly in regard to the removal of tuberculin non-responsive tuberculous animals in heavily infected herds (Monaghan et al., 1997).

The apparent absence of gross lesions of tuberculosis in tuberculin-reactor cattle and their subsequent classification as non-visible lesion (NVL) reactors is not an indication that such animals are not infected. *Mycobacterium bovis* was recovered from tissues taken from up to 10% of these animals (Corner, 1994). In such cases the history of the herd of origin of the animal, its own tuberculin testing history and evidence of other likely causes of reactivity to bovine tuberculin, such as the presence of skin tuberculosis or other mycobacterial infections in the herd, are of relevance when reaching a conclusion regarding the true tuberculosis status of the animal and its cohort.

The matrix of factors that influence the efficiency of detection of *M. bovis*-infected cattle before and after slaughter is illustrated in Figure 2.

Meanwhile the rate of disclosure of confirmed tuberculous lesions in attested cattle is a measure of the current efficiency of tuberculin testing programmes in herds deemed to be free of the disease. In countries such as the USA slaughter surveillance is the principal means by which infected herds are identified. Quality control on such monitoring is based on the rate of submission, by each meat plant inspectorate, of granulomatous lesions from slaughter animals for laboratory examination (Meyer, 1990).

Lesion disclosure rates in tuberculin-reactor cattle at commercial slaughter are influenced by the mode of examination in use at the plant in question, and may be as low as 47% of the actual lesion rate as confirmed by a more detailed examination (Corner, 1994). The lesion disclosure rate has recently been shown to be directly related to the degree of reactivity of the animal at its most recent tuberculin test, (O'Keeffe and Crowley, 1996), as shown in Table 1.
Figure 2. Matrix of factors affecting the efficiency of detection of *M. bovis*-infected cattle before and after slaughter.

<table>
<thead>
<tr>
<th>Detection of Cattle Infected with <em>Mycobacterium bovis</em></th>
<th>Live Animal</th>
<th>At Slaughter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OVERT-DIAGNOSIS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>due to - interference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSI</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>APPEARANT PREVALENCE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>detection failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre-responsive or non-responsive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>due to - anergy</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UNDER-DIAGNOSIS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>detection failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>due to - misdiagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>due to - inspection procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- kill rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- misdiagnosis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1. The lesion rate in groups of reactor cattle, as defined by their “skin measurement difference”, i.e. difference in skin thickness measurement at sites of injection of avian and bovine tuberculins in millimetres (After O’Keeffe and Crowley, 1996).

<table>
<thead>
<tr>
<th>Skin difference (mm)</th>
<th>Lesion rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0</td>
<td>13</td>
</tr>
<tr>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>1 - 2</td>
<td>14</td>
</tr>
<tr>
<td>3 - 4</td>
<td>20</td>
</tr>
<tr>
<td>5 - 9</td>
<td>30</td>
</tr>
<tr>
<td>10 - 19</td>
<td>46</td>
</tr>
<tr>
<td>20 - 39</td>
<td>56</td>
</tr>
<tr>
<td>40 or more</td>
<td>61</td>
</tr>
</tbody>
</table>

Conclusion
Changes in the form of presentation of *M. bovis* infection in cattle in the latter stages of eradication, together with modern changes in animal production systems and their impact on transmission (Collins, 1994), are further complicating factors affecting its control, and so the need to use every means available for the detection of infected animals remains a national imperative. Meat plant surveillance for tuberculosis in slaughter cattle can provide an effective means of monitoring the tuberculosis status of national herds (Costello *et al.*, 1997). In recent years, in the developed countries this aspect of meat inspection has come to be regarded primarily as an extension of the national animal health programme rather than as a critical control point in the prevention of human cases of tuberculosis arising as a result of consuming meat from tuberculous animals, as was the case a century or more ago. For this reason the nature of the association between the meat plant inspectorate and the agency responsible for the control and eradication of the disease at herd level needs to be re-assessed, if the true value of meat plant surveillance for this disease is to achieved. This is not intended to distract attention away from the zoonotic aspects of *M. bovis* infection in the slaughter animal, which has health implications for the consumer and also, as an occupational hazard, for the meat plant employee, or from the other public health responsibilities of the veterinary food hygienist. Rather, it is intended to place in focus the contribution which efficient meat inspection, coupled with real-time data retrieval and data transfer systems and supported by advanced diagnostic bacteriology including DNA-based strain typing, can make to the eradication of this disease in livestock. Such a re-appraisal of meat inspection procedures, and of the purpose and objectives of veterinary meat hygiene and inspection, was advocated by Berends *et al.* (1993). In this context the use of auditing systems, such as the optimal granuloma submission rates used in the USA and as described by Meyer (1990), referred to above, is relevant to the surveillance of culled dairy cows in particular.
The success of national bovine tuberculosis eradication programs in some countries has tended to lead to a loss of awareness, on the part veterinary food hygienists and their assistants, of this zoonotic disease and of its insidious nature. The hazard that this disease represents for food handlers and some consumers in these countries is considerable and warrants due vigilance at every stage of production, processing and distribution of meat, and dairy, products. Meat plant surveillance represents only one means of addressing this public health issue.

Detailed examination of tuberculin-reactor cattle at slaughter can lead to the detection of tuberculous lesions in a high proportion of cases and thereby ensure a better understanding of the nature of the problem on the part of the herd owner and his/her advisers. Consequently the careful examination post-mortem of lymph nodes and of the lungs, represents an important element of national tuberculosis eradication programmes, as well as being an integral part of the veterinary meat inspection programme.

Figure 3. The inter-relationships between the veterinary food hygienist and the field veterinarian in the eradication of tuberculosis

Complementary roles of

- protects consumer
- reduces occupational risk in meat plant
- reduces risk to the environment
- provides epidemiological data on distribution of strains of *M. bovis*

Field veterinarian

- protects
- national herd
- farm workers
- consumers of raw dairy products
- the environment

Finally, the observation that animals which show a high responsiveness to bovine tuberculin are most likely to display gross lesions at slaughter (Table 1), may provide a basis for the strategic removal of such reactors as a priority in developing countries in which financial constraints on a national eradication programme prevail.

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