DEER TUBERCULOSIS IN NEW ZEALAND: NATIONAL AND ON-FARM CONTROL

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Introduction

The first diagnosis of tuberculosis (Tb) in farmed deer in New Zealand was in 1978. An experimental preliminary evaluation of bovine tuberculin tests determined that the mid-cervical site was the most appropriate. This was subsequently validated as the most useful herd screening test. In the early 1980s Tb was diagnosed in farmed deer in the UK, presumed to be from Hungary. Subsequently Tb has been found in deer in most countries farming deer including Australia, USA, Canada, many European countries, and Taiwan, in addition to New Zealand. However, some deer farming countries such as China and Mexico do not have a Tb testing programme so their status remains uncertain. There are several instances of international spread via deer; eg. Europe to UK, UK to New Zealand and New Zealand to Canada. Thus, deer tuberculosis is indeed an international problem and is one that has occupied regulatory authorities, veterinary professions and industry organisations in many countries.

Every country has its unique circumstances contributing to Tb infections in farmed deer. In some countries the complexity of this disease is confounded by its presence in wildlife vectors such as the possum in New Zealand, badger in UK and feral deer in New Zealand and the USA. One of the significant concerns in livestock industries, particularly cattle, is that Tb in deer could threaten Tb eradication programmes or internationally declared Tb status of cattle herds.

Tb in deer has been widely studied in New Zealand, Canada, USA and UK, and significant work continues on improving diagnostic methodology in the live animal, the epidemiology of infection, vaccines and immunity, and genetic resistance.

This paper will describe the current New Zealand situation and experience of deer Tb, much of which is common to other deer producing countries. It is essential that practising veterinarians and regulatory authorities maintain an international brief on this disease since many circumstances and experiences in one country are relevant to the control and eradication of the disease in others. This presentation will also discuss a few key points of epidemiological research that has contributed to our ability to control and manage Tb on individual deer farms.

Global importance of Tb

Exporting countries

It is important for exporting countries to comply with the OIE International Animal Health Code chapter requirements for Declaration of Disease Status in relation to Tb. Currently that document is under review. For New Zealand, which exports approximately 98% of its deer products it is imperative that our Tb status fulfils the criteria so venison markets remain open. NZ authorities, and processors and exporters, are fastidious in ensuring that venison from Tb reactors does not enter the export market. There have been producers wanting to export live deer who have been frustrated that their district Tb status has precluded them from doing so. Moves to market velvet antler as a nutriceutical and functional food in the western hemisphere markets will mean tuberculosis will achieve greater importance.

Domestic suppliers

These are particularly important for the United States and Canada. Assurance of the domestic market is an important aspect of a likely increasing venison market locally. Increasing awareness of Tb in deer may reduce consumer confidence. In NZ, venison from Tb reactors, if it passed veterinary inspection, is sold only on the domestic market without comment from consumers, because they are largely unaware of its status of origin. The domestic market for velvet products for USA and Canadian producers may be influenced by consumer awareness of Tb.

The New Zealand deer Tb situation

History

New Zealand is fortunate in having good documentation of the occurrence of Tb in farmed deer, initially through a Ministry of Agriculture and Fisheries (MAF) database but now through the Animal Health Board's National Livestock Database. In 1986 there were 487 deer herds with infected status and therefore on movement control. In June 2001, 96 herds were classified as 'infected'. In 1985 a voluntary accreditation programme was implemented as a collaborative endeavour between the New Zealand deer industry, MAF and the New Zealand Veterinary Association based on whole herd testing. Accreditation involved three whole herd clear tests over a minimum of two years. By 1989 an estimated 60% of deer farms and 80% of the deer population were under whole herd test. In 1989 the Tb control programme became compulsory. Herd status is now referred to as 'clear', 'infected' or 'suspended', and as an indication of risk the number of years the herd had experienced that status is included, eg. C7 = whole herd clear test for 7 years.

Present situation

Figures 1 shows the current number of infected deer herds from 1996-2001. This shows a steady decline in infected herds.

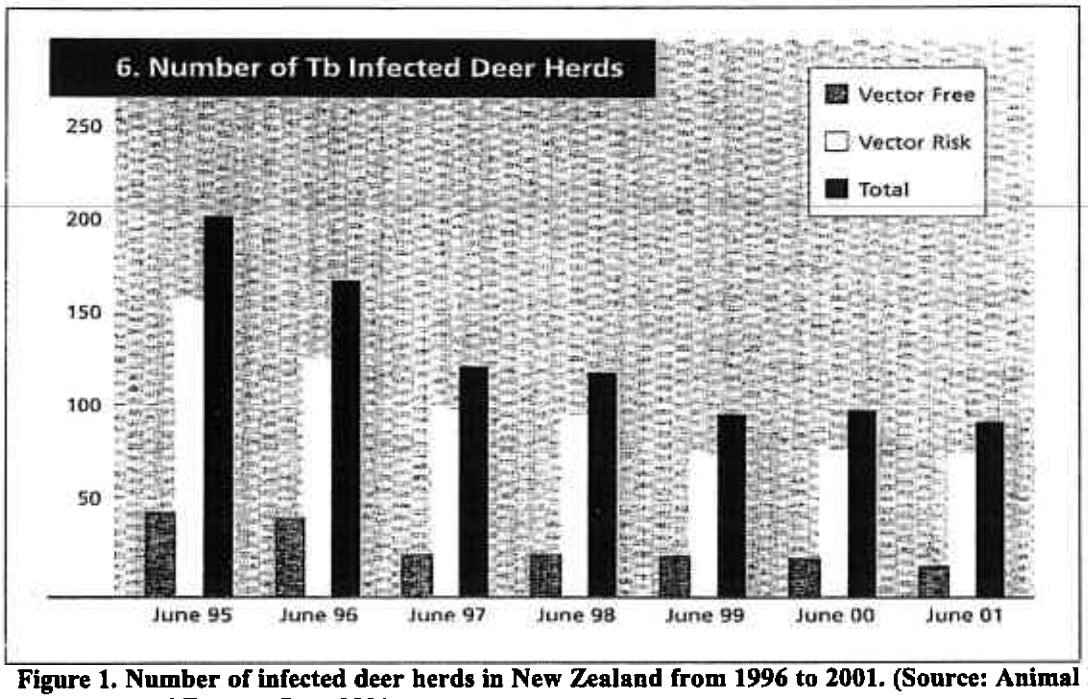

Figure 1. Number of infected deer herds in New Zealand from 1996 to 2001. (Source: Animal Health Board Annual Report, June 2001.

The "Vector Risk" category refers to areas of the country that contain Tb infected feral wildlife vectors, particularly the possum.

The deer Tb control scheme

Legislation

The Biosecurity Act 1993 allows for the establishment of Pest Management Strategies for unwanted organisms such as tuberculosis. For many exotic diseases MAF determines controls the management strategy. However, for endemic disease such as tuberculosis the mandate for developing a pest management strategy must come from "the industry". In the case of tuberculosis the cattle and deer industries combined, acknowledged the need for a control and eradication programme to protect our markets for agricultural produce. The government, upon agreement, provides the legal mandate for implementation of a pest management strategy and provides mechanisms to allow industry to gather the necessary funds. In New Zealand this is based on an "animal health levy" on venison and velvet from the deer industry. The cattle industry collects a similar levy. However, in addition, where there is deemed to be a public good related to the pest management strategy, the government will contribute tax-payer funding. In 2001-2 the expected expenditure on Tb control under this strategy is $78.4 million, with about $30million from the taxpayer.

Animal Health Board

The Animal Health Board is the body officially sanctioned to implement the pest management strategy for Tb. The Board is governed by appointed representatives from industry, science and government, and is managed by a team of administrators, planners, veterinarians and liaison personnel.

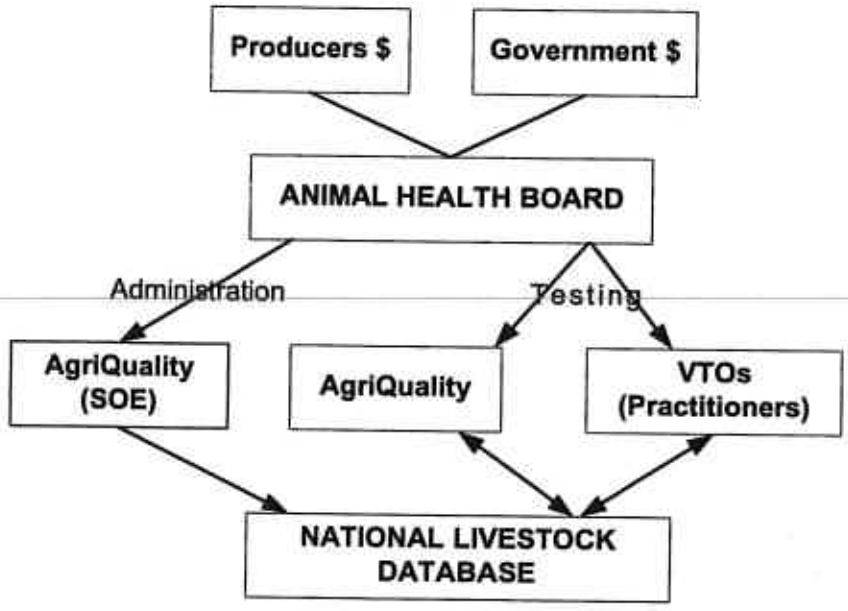

Figure 2. Schematic diagram of the relationship between the parties involved in deer Tb control.

The Animal Health Board reviews the pest management strategy on a five-yearly basis and this requires endorsement from industry through public consultation and political processes. The Board draws up the technical criteria for the Tb control programmes for both deer and cattle which define approved tests and testing requirements for deer and cattle under varying circumstances that exist throughout New Zealand, particularly those confounded by the presence of Tb-infected vector populations. In these instances, regional authorities are brought into the strategy, particularly for vector control. In addition, the Department of Conservation which manages the public estate, is involved as appropriate, with vector control.

The Animal Health Board contracts management of the Tb control programme currently to a state-owned enterprise (SOE) AgriQuality, which has a regional network of veterinarians and support staff, and which maintains a nationally linked livestock database for record keeping.

Deer Tb testing is undertaken largely by practising veterinarians through direct client-vet relationships. About 30% of deer are tested by AgriQuality staff. Thus there is contestability. Deer farmers pay directly for Tb testing whereas cattle farmers have Tb testing subsidised through their levy system.

The farmer nominates their preferred testing provider. The National Livestock Database automatically sends that service provider a computerised test allocation. The provider then arranges with the farmer a time to Tb test. The requirements of that test are stipulated on the allocation form. The testing officer is required to complete the details of that test and return them within a stipulated time to the AgriQuality office for entry into the National Livestock Database. While there are various regional schemes under regional veterinary direction, catering specifically for local situations, the responsibility for control and eradication of Tb on an

individual deer farm is that of the farmer in consultation with their testing service provider and/or advisor. The AHB-contracted AgriQuality veterinarians have some jurisdiction in assisting that process.

On-farm Tb diagnosis and control

Testing

The herd screening test used is almost exclusively the single intradermal mid-cervical bovine tuberculin test (MCT). In rare and well-defined circumstances, where a high prevalence of non-specificity has been proven in the absence of *M. bovis*, a comparative cervical test may be justified.

Test-positive result

Figure 3 shows the process for determining the most appropriate response to a test positive result at a screen test.

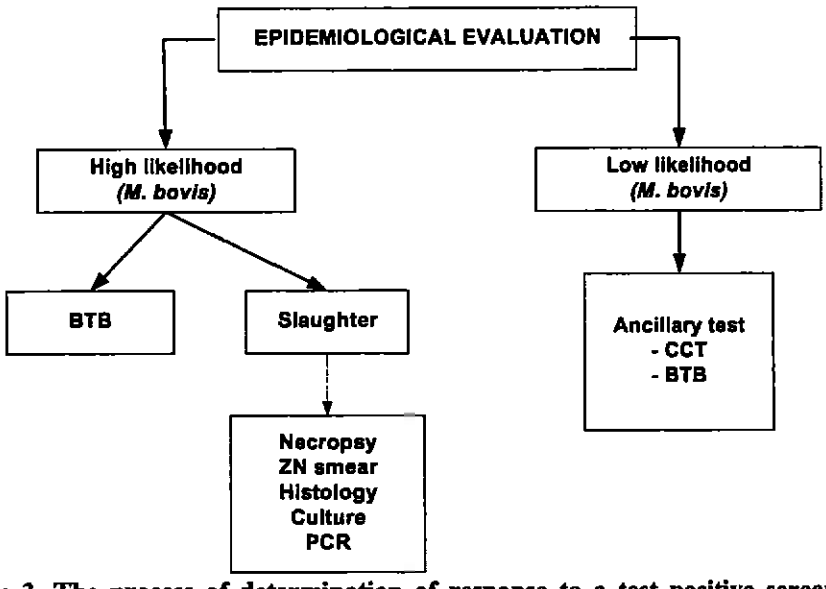

Figure 3. The process of determination of response to a test positive screen test, to determine the presence or absence of Tb.

A negative test result may indicate absence of infection, or failure to detect infection. A positive test could indicate infection with *M. bovis* or cross-reactive sensitisation to other mycobacterial or non-specific antigens. As the prevalence of Tb reduces, the proportion of test-positive animals that are non-specifically infected increases (ie: the predictive value of a positive test reduces). This is a particular concern for deer farmers since they perceive that the MCT is not "accurate" enough. This in fact is the most troublesome issue for the deer farmer within the Tb control scheme, and has the tendency to discredit the MCT and bring the scheme into disrepute. Veterinarians have a particularly important role in explaining the issue but even this is a problem because some vets have difficulty understanding and explaining concepts of test validity.

It is essential that veterinarians understand that the MCT, with an estimated sensitivity of 85% when using the interpretation that "any palpable or visible swelling" is positive, is an adequate test for detection of infected herds for a national Tb control programme. It must be understood that the unit of study is the herd rather than the individual. This is because the herd-based sensitivity is a combined function of the number of animals infected and the animal-based test sensitivity, eg. if two animals are infected the herd-based sensitivity increases to 97.75% and is almost 100% when the number of infected animals is three or more. Thus there is a considerably higher probability that the herd status can be accurately identified than the individual animal status, if there are two or more infected animals in the herd, which is likely with an infectious disease.

Determination of the risk that a test-positive result (ie. one or more deer) indicates infection or non-specific reactivity is the most crucial step for the veterinarian involved in interpreting the test result. Evaluation of the epidemiological risks of introduction or presence of *M. bovis* in that herd, taking into account previous history, stock movement, feral vectors, neighbouring properties, previous test results such as confirmed non-specificity/*M. bovis*, and recent slaughter surveillance results, determines the next step.

If the risk that Tb is present or has been introduced to the herd is high, either slaughter or use of a test with a high sensitivity (BTB) is advised. Conversely, if the risk is considered low the hypothesis that the test-positives are non-specifically infected is then investigated. This is usually undertaken with a comparative cervical test (CCT) or blood test (BTB). In addition, if carried out in detail this process often establishes the pattern of infection within the herd that can give vital clues to its management.

Ancillary tests

The CCT is the most commonly used ancillary test in NZ because most herds are not infected, and at the current prevalence, the proportion of test positive animals that are infected with *M. bovis* is low. A 90-day wait period is required to minimise the risk of reduction of sensitivity. This test has a lower and reportedly variable sensitivity than the MCT so it should be used with caution.

The BTB is a composite lymphocyte transformation (LT) and ELISA assay, read in parallel (ie. if either or both of the LT or ELISA are positive, the animal is considered infected), and has a reported sensitivity of 94-95%. It is commonly used in New Zealand.

A post skin-test ELISA is approved in New Zealand. This test can only be conducted 14-30 days after an intradermal skin test and is approximately 87% sensitive in that circumstance. This test has specific application in herds with a high prevalence of *M. bovis* infection to aid detection of skin test-negative infected deer, particularly those with advanced disease that have become anergic to MCT which relies on a cellular response, but which have mounted significant secondary (antibody) response detectable by the ELISA. Its combined use in parallel with the MCT, has a sensitivity in excess of 90%.

Slaughter of infected deer

It is compulsory that any deer known to be or suspected as being infected with Tb be identified with an approved Animal Health Board tag. The AgriQuality veterinarian responsible is notified and a condemnation order is placed upon that animal to ensure slaughter within 30 days. Tb reactor-identified deer can be slaughtered at slaughterhouses, but the carcass is

downgraded financially, because of the additional hygiene and inspection requirements, and because meat from test positive deer can be sold only on the domestic market.

On-farm management

Once a diagnosis of Tb is confirmed the farmer must undergo at least the minimum testing programme as stipulated by the Animal Health Board. However, in many situations simply repeat testing at the allowed maximum intervals is insufficient to contain the disease. Further, there has been resistance by deer farmers to repeat test at a frequency that will reduce the prevalence of disease and accelerate of herd status from infected to clear. One factor contributing to this reluctance may be a lack of planning, strategy, goal setting and direction resulting from lack of guidance and professional advice. Having to pay for the latter may be an added disincentive.

Testing and slaughter alone will often not be sufficient to eradicate the disease from an infected herd. There are a significant number of management strategies that can be implemented on a farm to accelerate the eradication of Tb from that herd. The veterinarian has a unique role in applying their skill and knowledge of Tb and its epidemiology, combined with knowledge of farm management systems, to assist the farmer in eradicating the disease rapidly.

Testing frequency is clearly a very important aspect, although if management of individual groups which may have a different prevalence of disease is not undertaken to reduce the risk of spread, repeat testing alone may be inadequate. Isolation and quarantine may be particularly important. Likewise, appropriate management of young stock and their relationship to older animals is vital. The choice of ancillary test in relation to the necessary wait time for that test also is important in either allowing the disease to persist or be eradicated.

One particularly useful strategy in herds where the prevalence of infection is getting to a low level is to split the herd into quarantine groups to be managed and tested separately. This has been used in some herds to identify groups of animals that contain persistent false negative skin test infected animals. Use of the post-skin test ELISA can then be targeted to that group or the entire group can be slaughtered. Where Tb infected wildlife vectors are present, a number of management practices can be implemented to reduce the risk of infection to deer and cattle (see Section on on-farm management below).

The Veterinary Profession's Tb Quality Assurance Programme

The Animal Health Board and the Chief Veterinary Officer of New Zealand require that Tb testing be only by approved, competent people subject to a quality assurance programme.

In response, the Veterinary Association in New Zealand developed a quality assurance programme for veterinarians wishing to Tb test deer initially, and more recently have expanded that programme to include cattle. A Tb Quality Standards Committee (TQSC) was established in 1994 with the mandate to produce a technical manual for veterinarians and establish and manage a QA programme for practitioners wishing to provide Tb testing and control services. This manual included all aspects of knowledge and understanding of Tb and the National Tb Control Programme, including specifications for the tests used, their compliance standards, and the rules of the programme. In addition, it included an extensive resumé of deer Tb epidemiology and an understanding of test limitations, the issues related to sensitivity and specificity, and individual on-farm management procedures. It also details the pathology of the disease, post-mortem technique, and the range of diagnostic aids. Thus, it is an advanced educational tool.

The intending Veterinary Testing Officer (VTO) joins the programme by purchasing the manual, and then undergoes an open book multiple-choice self-evaluation. Once that is approved by the TQSC, the vet then applies for an on-farm assessment by one of a specially trained network of Tb assessing officers (TAO) who are veterinarians regionally located. Once the veterinarian has demonstrated the ability to comply with the practical compliance standards, approval is then recommended.

The scheme has three levels of audit: continuous, based on the veterinarian's responses to Tb test allocation forms and their accurate completion and submission within compliance times; a TQSC internal audit process that may be targeted where notification is received that a VTO is not performing in according with compliance standards, or a random internal audit; and an annual external audit by the Animal Health Board and MAF reviewing documented evidence of compliance with this scheme.

This scheme is considered to be a world first quality assurance programme for private practising veterinarians involved with State veterinary medicine. The management of this programme is now undertaken by a subsidiary business of the New Zealand Veterinary Association called National Quality Veterinary Services Ltd.

Epidemiological research contributing to on-farm management

There have been numerous studies of the epidemiology of tuberculosis in New Zealand and elsewhere. The Massey University Deer Research and Epidemiology groups have undertaken a number of studies into deer tuberculosis.

Role of feral deer

A study of feral deer indicated that adults were twelve times more likely to be infected with Tb in areas where Tb is found in other wildlife vectors than in young deer. This indicates that spread of tuberculosis in feral deer in NZ is largely from other feral vectors rather than via vertical transmission from mother to offspring. This research suggested that the prevalence of Tb in feral deer would reduce substantially if the prevalence in other wildlife vectors such as the possum was reduced.

Pathogenesis

These studies of natural infection confirmed earlier experimental observations that the oropharyngeal tonsil may have been the primary route of infection. Sixty-one percent of infected deer were culture-positive from the oropharyngeal tonsil, although only half of those tonsils contained lesions suggestive of tuberculosis. In some animals the tonsil was the only infection site. Fifty percent more animals had tonsils infected than retropharyngeal lymph nodes infected. This demonstrates the importance of culturing tonsils in suspect tuberculosis animals.

Inquisitiveness of deer

A comparative study of sheep, cattle and deer showed that deer were rather more curious than cattle, and would approach foreign objects such as sedated possums more readily than cattle. Sheep rarely approached sedated possums. This study suggested that the major route of infection to deer was by direct contact with moribund infected possums lacking the energy to avoid contact with deer.

Epidemiology of Tb in vectors and vector ecology

A substantial amount of work has been undertaken to define the epidemiology of Tb in feral wildlife vector populations, and vector ecology. Of particular note is the possum. Studies have shown that Tb tends to be seasonal and is a progressive disease in possums. Eventually moribund possums, many of which have Tb discharging lesions, will migrate onto pasture and therefore be accessible to livestock. Further, a number of studies have been done to identify risk sites in the habitat for Tb-infected possums.

Natural infection with Tb

Deer paddocks were constructed in an ecosystem where Tb was present in feral possums. Six deer were introduced and tested over approximately 12 months. Five became infected. Behavioural studies indicated that the deer highest in the dominance hierarchy were the most inquisitive and these became infected first. The study provided the first evidence of the method for natural transmission of Tb infection directly from possums to deer.

On-farm management

The hypothesis of the Massey group was that the eradication of Tb from infected herds can be accelerated by application of knowledge of the epidemiology of the infection and the relationships between vector ecology and farm management. A PhD programme indicated that with targeted vector control, coupled with management to reduce the risk of direct contact between vector and livestock at the high-risk times of year, significantly shortened the period to eradication of the disease. The same principles are applied to reducing the risk of re-introduction of Tb to the herd from infected vectors.

It is notable that the Animal Health Board has adopted the findings of this study and is now establishing special management groups for helping the farmer manage the farm in a way that reduces the risk of re-infection of livestock.

Acknowledgements

Members of the EpiCentre, Massey University, including Professor Roger Morris and graduate students Ian Lugton and Carola Sauter Louis, along with Dirk Pfeiffer, now at the Royal Veterinary College London, are acknowledged for their research summarised in this section.