ISSN 0370-2731/2001 Proceedings of the New Zealand Society of Animal Production **61:** 57-59

Possums as vectors of Tb in livestock

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ABSTRACT

Bovine tuberculosis (Tb) is the most important disease of livestock in New Zealand, and it occurs in cattle and deer herds at relatively high incidences by international standards. Brushtail possums are the major wildlife vector and maintenance host of Tb in New Zealand, and their infection is the single greatest barrier to the eradication of Tb from New Zealand livestock. The control of infected populations of possums underpins attempts to eliminate the disease from livestock. Possum populations infected with Tb occupy about 24% of New Zealand, which is also where about 75% of the reactor herds and Tb-infected cattle occur. Possums with Tb often exhibit lesions in their lungs and external lymph nodes and infection in these sites appears to be involved in the transmission of the disease to other possums. The mode of transmission of Tb from possums to livestock is unproven, but it is thought to occur when inquisitive stock encounter dying possums.

Keywords: Possums; cattle; bovine Tb; epidemiology; Tb transmission.

INTRODUCTION

Brushtail possums (*Trichosurus vulpecula*) now occur over approximately 90% of New Zealand, including all farming areas. Their numbers have been estimated at 60-70 million (Batcheler & Cowan, 1988), and their highest densities (up to 25/ha) often occur on farm/forest boundaries, where they have the opportunity to interact with livestock. Numbers of possums are generally lower on farmland away from forest cover; where densities range from 1/ha on scrubby farmland to 5-10/ha about streamside willows and swamps (Cowan, 1990).

Bovine tuberculosis (Tb) is an introduced disease in New Zealand caused by *Mycobacterium bovis*. It is the most important disease of farmed cattle, and occurs at relatively high incidences in New Zealand herds by international standards. This is in spite of local, long-running, internationally-accepted herd test-and-slaughter programmes and carcass inspection programmes at abattoirs aimed at the detection and eradication of Tb.

Tuberculosis was first seen in possums in 1967 (Ekdahl *et al.*, 1970). A seemingly intractable Tb "problem area" for cattle at Waimangaroa, north of Westport in Buller County, had been identified from unexplained local upsurges in the number of tuberculous cattle. A search for a source of infection in wild animals identified tuberculous possums coexisting with the chronically infected cattle herds. Soon after this discovery, infected possums associated with infected cattle were identified elsewhere in Buller County, and then in rapid succession in the late 1960s and early 1970s in other widely dispersed areas of New Zealand. Similar infected possum populations have also been identified about infected farmed deer.

Tb-infected possum populations now occupy about 24% or 6.24 million hectares of New Zealand (Animal Health Board (AHB), 1998). They occur in five major areas, namely the central North Island, Wairarapa, Westland, North Canterbury, and Otago, and in at least 15 discrete areas in Southland, Banks Peninsula, Nelson/Marlborough, Horowhenua, Manawatu, Hawke's Bay, and Auckland. When combined, these areas (termed Vector Risk Areas (VRAs) by the AHB) contain 75% of New Zealand's infected cattle herds and reactor cattle. Within VRAs, tuberculous possums have been found in a variety of habitats and locations, with prevalences often highest in possum populations foraging on pasture adjacent to the forest edge. Initially, infected populations were principally confined to the high rainfall areas of the West Coast and lower and central North Island. Now infected populations also occur across extensive areas of dryland beef farming.

The possum is considered the primary wildlife reservoir of Tb for farmed cattle and deer in New Zealand, and continuing transmission of Tb from tuberculous possums to livestock is the single greatest barrier to the eradication of the disease from New Zealand livestock. Other species of wildlife, particularly red deer and ferrets are know to harbour Tb and are also suspected of transmitting it to livestock, but possums are believed to be the key wildlife host in most localities (AHB, 1998).

EPIDEMIOLOGY OF TB IN POSSUMS

Pathology

The pathology of Tb in possums shows that they are inherently highly susceptible to *M. bovis* in ways that may predispose them to become sources of infection for other animals. Naturally occurring Tb in possums is characterised by numerous grossly visible (macroscopic) and sub-clinical (microscopic) lesions (abscesses). Macroscopic lesions occur in infected possums in up to 10 distinct body sites (Coleman, 1988), and for possums at one research area (Ahaura, Jackson *et al.*, 1995), averaged 4.6 sites per infected possum. Microscopic lesions have been identified at twice as many sites as those in macroscopically infected possums, indicating a high level of generalisation of the disease (Cooke *et al.*, 1995). Lesions are most common in the lungs and in the superficial lymph nodes (75% of all macroscopically lesioned possums; Fig 1), closely followed by infections in the liver (Coleman & Caley, 2000). Lesions in superficial and deep lymph nodes can be up to 60 mm in diameter, and up to 30% of infected possums, may be exhibiting lymphatic discharge to the exterior via sinuses (artificial openings; Cooke *et al.*, 1995). These animals excrete large numbers of tubercule bacilli and are therefore highly infective. Levels of infection (point prevalences) in possum populations typically range from

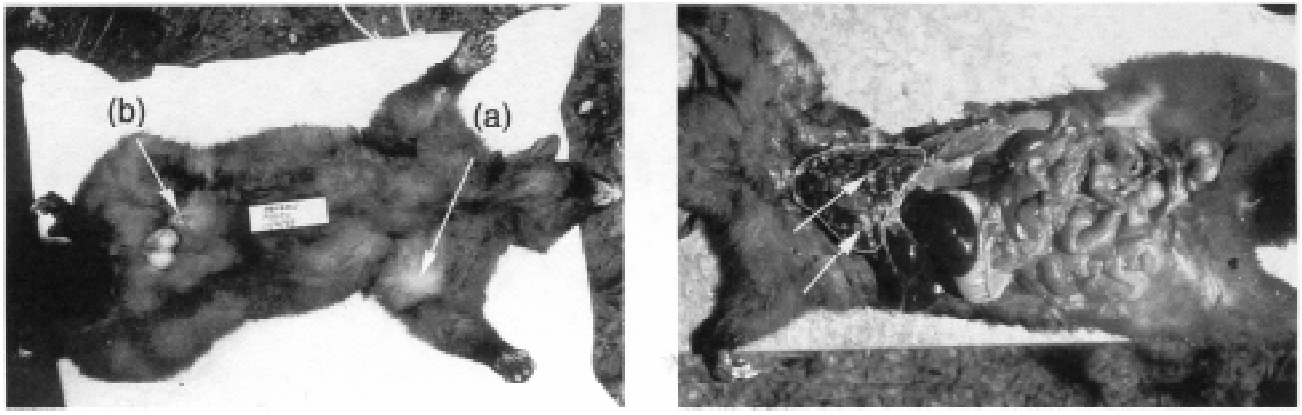

FIGURE 1: Tuberculous possums showing grossly infected axillary (a) and inguinal (b) lymph nodes, and widely disseminated lesions in the lungs.

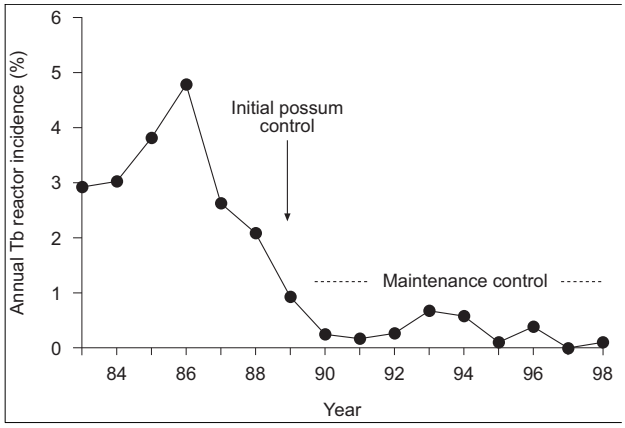

FIGURE 2: The reduction in incidence of Tb in six dairy herds near Hohotaka following the control of local infected possum populations (after Caley 1997).

1-10% and average 5% (Coleman & Caley, 2000), but occasionally may reach as high as 60%. Such levels, together with the widespread nature of the lesions providing potentially simultaneous spread of the disease by blood vessels, airways and lymphatics (Cooke *et al.*, 1995), and the paucity of single site infections in individual animals indicate that possums are highly susceptible to Tb.

Routes of infection and excretion

Routes of infection are indicated by the location of single site infections. As these are most common in either the lungs or the superficial lymph nodes, the most likely route of possum-to-possum infection appears to be via the respiratory tract. The two major pathways for possum-to-possum spread of Tb are thought to be either pseudo-vertical (mother to young) or horizontal (between free-living animals). Pseudo-vertical transmission involves the close association between a mother and her young, during suckling and grooming, with Tb spread occurring during respiration or via milk or the discharging sinuses of the mother. Where mothers are known to be infected, 100% of their pouch young subsequently become clinically tuberculous (Coleman and Cooke, unpublished data). Horizontal spread is most likely to occur during courting and mating, fighting between males, or simultaneous den sharing.

The main routes of excretion of *M. bovis* from tuberculous possums are oro-nasal (bacilli excreted from the lungs), cloacal (in urine and faeces; bacilli from kidneys, lungs, and mesenteric lymph nodes), or via discharging sinuses. That said, most possums with macroscopic lesions are likely to be excreting *M. bovis* from one or more routes at any one time. In particular, pulmonary lesions provide many opportunities for airborne excretion of bacilli (Cooke *et al.*, 1995).

TRANSMISSION TO LIVESTOCK

Tuberculosis in cattle is primarily a respiratory disease and Francis (1947) estimated 80-90% of affected cattle are infected by inhalation of the bacillus. The mode of transmission between possums and cattle is difficult to study and therefore less well understood, as healthy possums avoid stock wherever possible and provide few situations for the close contact seemingly necessary for Tb transmission. However, direct observations of grazing stock and possums and evidence from DNA restriction endonuclease analyses (fingerprinting) of Tb bacilli, which show similar isolates in both hosts (de Lisle *et al.*, 1995), suggest such avoidance may not always be possible. Dominant cattle have been observed to approach semi-sedated ("sick") possums from up to 50 m away, and sniff and mouth them (Paterson & Morris, 1995). A parallel study of captive deer deliberately exposed to infected possums led to the dominant animals becoming infected (Lugton *et al.*, 1997), and it seems clear that exploratory behaviour by both cattle and deer is likely to expose them to infection. In contrast, sheep show much less interest in investigating sick possums. Although tuberculosis in sheep is a rare disease, as it is for goats, it is known to occur occasionally on farms with a history of Tb infection in possums. The rarity of such occurrences appears to rule out spread via contaminated pasture. Inquisitiveness in stock does not appear to extend to their inspection of dead possums, indicating that possum carcasses are unlikely to play a major role in the direct transmission of Tb to livestock. However, infected possum carcasses are thought to be an important source of infection for scavenging wildlife such as feral ferrets, stoats, feral cats, and feral pigs, and some or all of these species may occasionally be intermediate hosts between possums and livestock. Reduction of Tb prevalence in wild deer following possum but not deer control, indicates that transmission between possums and wild deer occurs (Nugent *et al.*, 2000).

The mode of transmission from livestock back to possums is unknown. However, recent studies, e.g., Nugent *et al.* (2000) have established that some possums scavenge animal carcasses, providing opportunities for both direct

(from livestock carcasses) and indirect (from wildlife carcasses) transmission of Tb from livestock to possums.

EFFECT OF POSSUM CONTROL ON TB IN LIVESTOCK

Possums are now recognised as the most important vector of Tb for most infected herds in New Zealand, and over the last three decades, there has been an intense ongoing effort directed at controlling local populations of infected possums. Such vector control cost $NZ28.4 million in 1998/99 (including monies spent on other wildlife vectors). The high cost of such control is not surprising; veterinary experience indicates that the most difficult diseases of livestock to control are those in which wildlife are also involved. That said, historical possum control data principally from the West Coast but also from other parts of New Zealand have shown that reducing possum populations about infected herds has enabled such herds to become, and to remain, free of Tb for varying lengths of time, depending on the extent of the initial reduction in possum density and whether possum numbers were kept low through ongoing maintenance control. As one example, epidemiological investigations in 1971 in Westland found an association between herds that had become reinfected with Tb and the control history of local Tb-infected possums (Stockdale, 1976); in another example the effectiveness of initial control of possums followed by annual maintenance control was well illustrated by results from a 15 year study at Hohotaka (Fig 2). There, the mean annual incidence of Tb in six herds was reduced by 88% over 10 years, and most if not all of this reduction was attributed to a reduction in the number of possums through annual control (Caley, 1997).

CONCLUSIONS

Direct and indirect evidence of the role of possums as a reservoir host for Tb in livestock includes:

- the persistence of Tb in possum populations in the absence of readily explainable sources of infection,
- the apparent transfer of *M. bovis* organisms from tuberculous possums to other wildlife species living contiguously with livestock,
- the common concurrence of infection in possums and coexisting cattle or deer herds,
- the reduction of the incidence of Tb infection in livestock following the effective control of tuberculous possum populations, and
- evidence from DNA fingerprinting which implicates possums as the source of Tb in cattle.

The risk of infection to cattle from tuberculous possums is the result of a number of aspects of possum ecology and behaviour. These include:

- relatively high possum densities on forest pasture boundaries,
- a strong preference for feeding on pasture (and thus amongst livestock),
- a high prevalence of Tb in possums denning within foraging distance of pasture, and
- the inquisitive behaviour of livestock towards terminally ill possums.

As possums appear to be a most effective wildlife reservoir, their abundance amongst livestock throughout New Zealand and the accessibility of their carcasses to scavengers makes the problem of Tb in livestock particularly intractable. For this reason, intensified and more widespread control of possums across all infected populations is now proposed as a new national pest management strategy (AHB, 2000).

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