Ferrets (*Mustela furo*) and bovine tuberculosis (*Mycobacterium bovis*); the need for a multi-species approach

Justine Ragg, Henrik Moller, Ken Waldrup and Colin Mackintosh
Department of Zoology, University of Otago

The major problem with the control of bovine tuberculosis (Tb) caused by *Mycobacterium bovis* in New Zealand is the reinfection of cattle and deer in areas where tuberculous feral/wild animals are present. Traditionally, the brushtail possum (*Trichosurus vulpecula*) has been considered the only significant wild animal vector but recent evidence suggests ferrets (*Mustela furo*) may also be important.

The high prevalence and wide geographical spread of Tb infections in ferrets, their association with infected cattle herds especially in areas of low possum density and the potential for ferrets to be infectious, suggest that ferrets may be involved in the transmission of Tb to livestock (Walker *et al.* 1993, de Lisle *et al.* 1993; Ragg *et al.* 1995a; 1995b).

All these inferences remain circumstantial but indicate that a significant role in transmitting Tb to stock by ferrets is potentially possible. Evidence for a role of possums alone in spreading the disease to stock is also circumstantial. Reduction in the incidence of Tb in stock following 1080 poisoning of possums has been used as evidence for the possum's role in the transmission of the disease to stock (Livingstone, 1986). This inference may be misleading if non-target species, which are involved in the epidemiology of the disease, are also killed. A study at Milton found a decline in ferret numbers following a 1080 poisoning operation targeting possums (Moller, *et al.* unpublished). Animal control operations should take a broader view of the ecological community.

It is difficult to assess the relative contribution ferrets are making because of an absence of experimental evidence of responses in the incidence of cattle Tb following selective removal of each potential vector.

How are ferrets becoming infected with Tb?

Ferrets may become infected through ingestion of infectious material, or by ferret to ferret transmission through social contact like den-sharing, mating, fighting and rearing. Ferrets are carnivores and they are known to scavenge carrion (Allen, 1991). The mesenteric lymph node was a common site for single-site gross *M. bovis* lesions which suggests that oral ingestion is a common route of infection (Ragg *et al.* 1995b).

Some ferrets may become infected by eating tuberculous possums but this is unlikely to be the only source of infection. Tuberculosis has not been detected in the possum population at Table Hill since May 1992, whereas the ferrets have maintained high prevalences of infection (Table 1). While still possible, it does not seem likely that the possum population can be responsible for the high prevalences observed in the ferret population. DNA typing results support this hypothesis; 7 out of 8 ferrets sharing a different strain of *M. bovis* to the organism isolated from only tuberculous possum within the study habitat (Ragg *et al.* 1994). This result also suggests that ferrets are capable of acting as maintenance hosts in certain areas.

Table 1: Feral and wild animals collected from Table Hill, Milton.

Species	No. with *M. bovis* lesions	Sample size	Prevalence 95%C.I.	DNA strain typing of *M. bovis* isolates
Possums	1	394	0.025%	Strain 1
			(0.007<μ<1.48)	
Ferrets	20	76	26.3%	Strain 1: 1 ferret
			(16.5<μ<37.4)	Strain 2: 7 ferrets
Stoats	1	14	7.1%	Strain 1
			(0.18<μ<33.9)	
Feral cats	2	53	3.7%	Strain 1: 1 cat
			(0.47<μ<0.13.1)	Strain 2: 1 cat

Although *M. bovis* infection has been found in most mammals in New Zealand, little is known about the extent that each host plays in the epidemiology of Tb. Until this has been discovered by means other than detection of gross lesions at necropsy, progress on the understanding and control of the disease will be slow. Some species may have been overlooked or their importance underestimated because they show little or no clinical signs of infection. Such species could be involved in the maintenance of infection in wildlife. Also few multi-species studies have measured relative population abundances and prevalences of Tb in different species occurring in the same area.

Peripheral lymph nodes contributed to 24.5% of all single-site gross lesions in 94 tuberculous ferrets, suggesting that some transmission by social contact also occurs (Ragg *et al.* 1995b). During the breeding season, both male and female ferrets were found to have serious skin wounds presumably inflicted through fighting and mating. In ferret populations, infections by this route may occur at rates high enough for the disease to be self-sustaining.

Does it matter if the vector is a spillover or a maintenance host?

Morris *et al.* (1994) hypothesise that only maintenance hosts are important targets for control. But this is a logical deduction only if effective and long-term control of maintenance hosts is possible and that eradication of Tb from endemic areas is a realisable goal. If the more immediate goal is to reduce Tb incidence then even spillover hosts are worthy targets for control provided that either they increase cycling of the disease amongst the wildlife that are involved in the transmission of infection to stock, or they themselves are infecting stock. It is possible that ferrets act as an important link in the transmission of Tb to livestock.

The ability to maintain the disease within a population is quite a different issue from whether the population threatens stock. We believe that if ferrets transmit tuberculosis to domestic stock then from a disease control point of view they should be important targets for research and possibly control. The real objective of Tb research in New Zealand must be to reduce the incidence of Tb in livestock less frequently than a spillover host.

Despite 20 years of possum control in New Zealand, the Tb problem is still spreading. Either the control of the main reservoir species is not effective enough to control tuberculosis in stock or Tb infections in stock are not wholly driven by infected possum populations. If ferrets are spillover hosts then the disease will only be controlled in the long-term by the successful identification and control of the infection source.

The need for a co-ordinated multi-species, multi-disciplinary approach

If ferrets are involved in the transmission of Tb to stock, it is necessary to learn more about predator-prey interactions in order to assess the ecological effects of ferret population control.

Our call for a more multi-species approach is particularly prudent when there is little reliable knowledge about the key determinants of incidence of Tb in stock. Until there is a multi-species ecological approach to the Tb problem we will never be able to reliably determine the relative contributions of each species to the problem, nor separate out the determinants of infection in each species. It is only when the total ecological problem presented by bovine tuberculosis infection in New Zealand is appreciated and understood, that there can be any progress on the understanding of the transmission of the disease and how best to control it.

In view of the high costs of the present Tb control programmes, threat to livestock market access, and the high investment of New Zealand in its agriculture industry, the risk that ferrets and other species are implicated should not be ignored.

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