Epidemiological information to establish individual farm TB management programmes

J.S. McKenzie, C.M. Sauter-Louis, R.S. Morris, P.R. Wilson

Abstract

The development of individual farm tuberculosis (TB) management plans is an important component of the National Pest Management Strategy to facilitate the eradication of TB, in particular from persistently infected cattle and deer herds. Key features of a TB management plan are intensifying possum control in TB hot spots and adjusting grazing programmes to keep cattle and deer away from hot spots during the periods when the risk of TB transmission from possums is highest. The epidemiological information supporting these features is presented, together with a description of various resources which may assist veterinarians develop TB management plans on clients' farms. The findings of a study which showed that supplementing regional-level TB management programmes with individual farm programmes reduced the incidence of TB in cattle and reduced the length of time for which a farm was on movement control is also presented.

Introduction

There are many situations where implementation of an on-farm TB management programme may be of value to an individual farmer, and to achieving the national goal of eradicating TB. These include:

- chronically infected farms where TB-positive cattle or deer persist despite standard regional control measures,
- infected farms in areas where there is no regional control, or
- infected farms where control has recently been initiated.

With respect to the first scenario, the Animal Health Board (AHB) has recognised that the establishment of individual farm management plans for farms defined as having a chronic TB infection is an effective way of overcoming the problem. Criteria for defining chronically infected herds and the composition of the advisory group are described elsewhere in this proceedings (Hutchings, 2002).

In relation to the second scenario, there are still a number of areas where TB is endemic in the possum population, which have not yet been included in regional-level control programmes. There is evidence that implementing an on-farm TB control programme in such areas results in a lower incidence of TB-positive cattle compared with farms that implement no control (Sauter-Louis, 2001).

In relation to the third scenario, supplementing regional-level control on beef breeding farms in areas that are receiving standard regional-level control has also been shown to reduce the incidence of TB-positive cattle and get farms off movement control more quickly (Sauter-Louis, 2001).

The objective of this presentation is to review aspects of the epidemiology of TB in possums that are relevant to the design of on-farm TB control programmes, to discuss key aspects of on-farm control programmes, and to present the results of a study that compared the pattern of TB on farms with and without an individual on-farm TB management programme. The paper focuses on possums as they are the most important wildlife vector of TB in New Zealand (Morris et al., 1994).

Epidemiology of TB in possums

Spatial and temporal distribution of TB in possums

TB in possums is spatially clustered in what is commonly referred to as 'hot spots'. These are generally small areas of the scale of 40-100 meters (McKenzie, 1999), and are found to be associated with possum denning areas (Pfeiffer, 1994). McKenzie (1999) found locations with multiple fully enclosed den sites were 3 times more likely to be hot spots than sites with no such den sites. This suggests that habitat factors are associated with hot spot locations by way of influencing the type and abundance of possum den sites. Such areas with favourable den sites are likely to support localised clusters of possums where the high contact rate between possums in the vicinity of their dens maintains the infection at that location. There is variation between areas with respect to the particular habitat that provides favourable protected den sites. One study conducted in the central North Island and in some parts of south-eastern North Island and Wellington found locations on the flat with multiple large trees were more likely to be hot spots (McKenzie, 1999), whereas at the site of an 11-year longitudinal study of TB in possums at Castlepoint on the Wairarapa coast, very steep hillsides with gorse and flax were more likely to be hot spots.

Many hot spots have been found to persist at the same location for many years (Caley et al., 2001). Despite this persistence, the prevalence of TB in hot spots fluctuates considerably over time. The prevalence of TB found in the 11-year study of an infected possum population at Castlepoint is shown in Figure 1. In a population that fluctuated between 150-285 possums, the proportion of TB possums fluctuated between 0-20% (Pfeiffer, 1994; Jackson, 1995; Lugton, 1997). For an 18-month period there was only 1 infected possum in the population (Jackson, 1995). There is also evidence that the prevalence at different hot spots fluctuates independently of neighbouring hot spots (McKenzie, 1999). McKenzie (1999) found that the incidence of TB in cattle on a farm was generally independent of its neighbours. Space-time analysis of the REA sub-types of TB at the Castlepoint study site show different REA types to predominate at different times. Lugton (1997) hypothesised that this pattern arose as only certain tuberculous individuals act as effective disseminators, and probably do so intermittently and only under certain circumstances. Further anecdotal evidence for variable fluctuation in TB prevalence at neighbouring hot spots is available from farmers who have noted that outbreaks of TB in cattle were associated with different parts of their farm in different years.

Other wildlife indicators of possum TB

The fluctuating prevalence of TB in localised possum populations results in cross-sectional post mortem surveys of possums being a very insensitive way of locating TB in possums. When a survey is conducted in a location where there has been evidence of transmission of TB between possums and cattle, it is quite possible that no TB possums will be found as that responsible for the outbreak has died and no other possums with detectable lesions are present in the population. Ferrets become infected by consuming carcases of possums that have died of TB (Lugton, 1997). Caley et al. (2001) found a strong association between possum abundance and the prevalence of TB in ferrets. When possum population was controlled the prevalence dropped which is hypothesised to be a result of fewer TB possums in the population. This suggests that ferrets are a reasonable indicator of the TB status of the surrounding possum population. Ferrets have been proposed as a more sensitive indicator of the general location in which TB is present in the wildlife population, up to a one-hectare radius from the location of the TB ferret.

Wild pigs also become infected by scavenging carcases of animals that have died of TB, and can be a useful indicator of the presence of TB in the wildlife population. However, their large home range makes it difficult to narrow down the location of the infected possum population(s). On very large properties a survey of wild pigs may be an indicator to stratify the property into coarse risk areas.

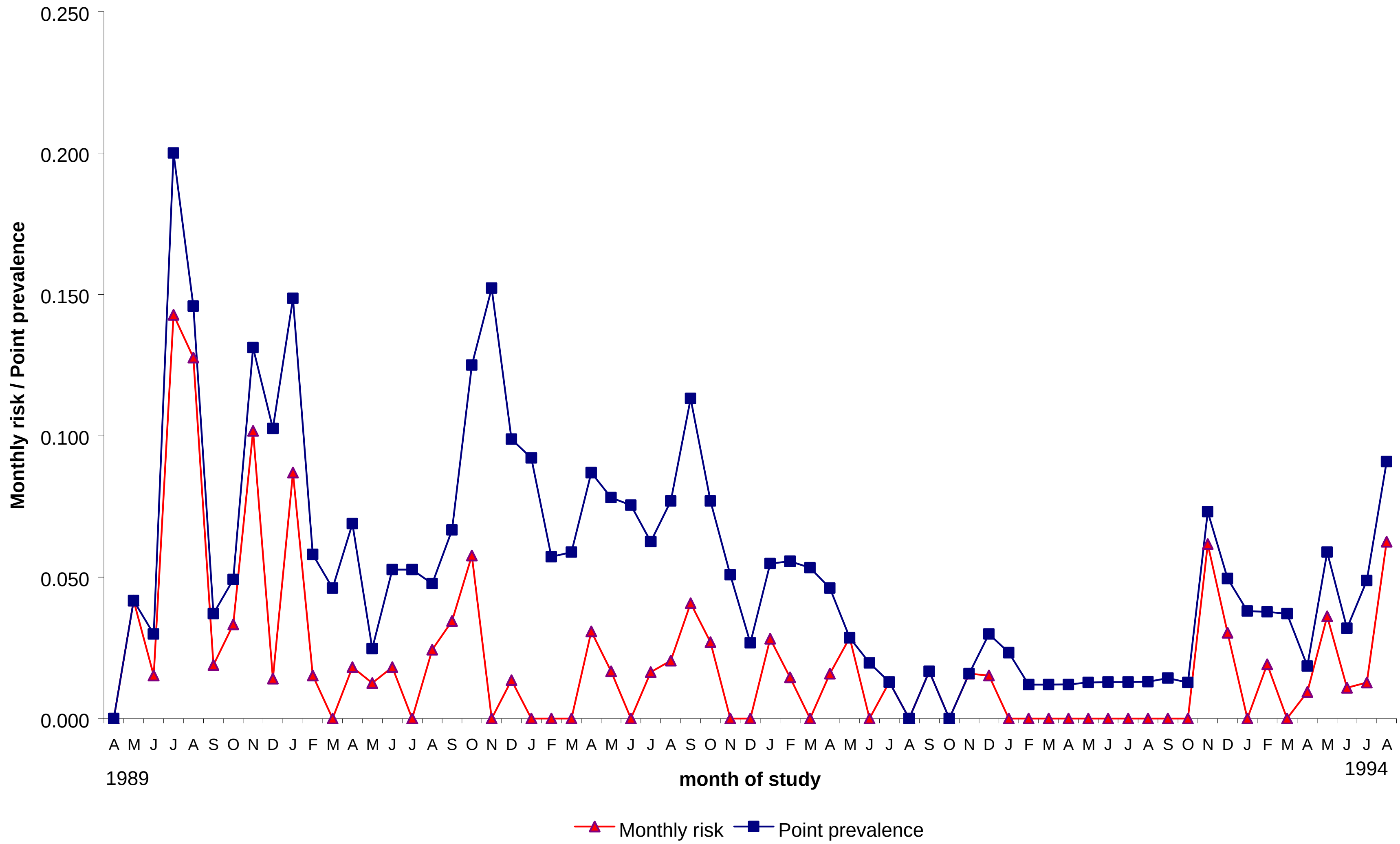


Figure 1. Monthly risk (incidence) and point prevalence of TB in possums during the first 5 years of a longitudinal study of a TB-infected possum population at Castlepoint, south-eastern North Island (R. Jackson, pers. comm.)

Transmission of TB from possums to cattle

Cattle and deer become infected with TB by investigating possums in the terminal stage of the disease when the possums have become weak and disoriented and may wander onto pasture during daylight instead of denning (Paterson, 1993; Morris et al., 1994; Paterson and Morris, 1995; Paterson et al., 1995). Sheep, on the other hand, were found to be less inquisitive and maintained a distance of at least 5 metres from the possum (Sauter and Morris, 1995). Sheep are as susceptible to TB as cattle and deer. However, they appear less likely to become infected due to their more cautious behaviour. Similar studies were conducted with ferrets. While cattle and deer investigated the sedated ferrets they spent less time in close proximity and were less likely to have direct physical contact, in the form of sniffing or licking (Sauter and Morris, 1995). This would suggest that transmission between ferrets and cattle or deer is less likely to occur than between possums and these same species. Furthermore, if it does occur it is more likely to result in single reactor animals.

Designing an on-farm TB management programme

The key features of an on-farm TB management programme are:

- Identifying most likely possum TB hot spot locations
- Conducting possum control in hot spot areas
- Adjusting cattle and/or deer grazing so that stock are away from hot spots areas during high TB-risk periods.

Each of these steps is discussed in more detail.

Identification of hot spots

Information that can assist with the identification of hot spot locations is described below.

1. The best indicator of a hot spot location is finding a TB possum(s), either through previous surveys, or farmers taking sick or dead possums to the local AgriQuality office or veterinarian for post mortem examination. However, conducting a post mortem survey of possums is not an effective way of locating hot spots, as described above.

2. Scavenging wild animal species are a more sensitive indicator of the location of possum TB hot spots than surveys of possums themselves. The two best species for this purpose are wild pigs and ferrets. Due to the larger home range of pigs these do not give a very precise indication of the hot spot location; it may be anywhere within a 3-4 kilometre radius of where a TB-positive pig was captured. However, the smaller home range of ferrets makes them a more precise indicator. A possum TB hot spot is likely to be within a 1-kilometre radius of the capture location of a TB-positive ferret.

   Anecdotal evidence from farmers suggests that wildlife surveys have been most effective in accurately identifying hot spots when they have been implemented over a number of years. This can be achieved by using control methods that enable recovery of the body, enabling post mortem examination of animals as a part of control measures. The cost of such on-going surveys may be compensated for over time by reduced cost in wildlife control by tightly focusing on the highest risk location(s), and more effective TB control resulting in fewer TB-positive cattle or deer and a higher chance of achieving freedom from disease.

3. High-risk areas of a farm may be identified by farmer observations that link TB patterns in cattle or deer to grazing in particular locations of the farm. This is most likely to occur on farms where different mobs are grazed on different parts of the farm. It is least likely to occur on farms where the cattle or deer rotation includes the whole farm and animals are only tested once a year, making it virtually impossible to identify where the animals became infected.

4. Habitat patterns can provide an indication of where possum TB hot spots are more likely to be located. High-risk habitat represents that which is most likely to provide multiple fully protected possum den sites. This may vary between regions, due to variation in predominant land cover species, and will require some local knowledge to identify potential hot spot locations. High-risk habitat in central and south-eastern North Island areas are large trees such as *Podocarp* or broadleaved forest species and old willows on flat land, and flax or gorse on very steep slopes, where gorse is interspersed with other tree or scrub species. Staff from the local AgriQuality office or the Regional Council who have been involved in previous surveys of possums may be able to indicate local habitat that is likely to be associated with the capture locations of TB possums and/or habitat that provides preferred possum dens.

Focused possum control

Possum control should be focused on the potential hot spot locations on a farm. Intensive control conducted once a year was shown to be associated with a reduction in cattle TB incidence (Sauter-Louis, 2001). The two periods when intensive control is likely to be most effective in reducing the prevalence of TB-infected possums is: (1) when the prevalence of TB is likely to be highest in the possum population, and (2) when juvenile possums have recently migrated into the area, increasing the risk of immigrant TB infection. A graph of the average monthly point prevalence of TB, calculated from the first 7 years of the longitudinal study at Castlepoint (**Figure 2**), shows that the highest prevalence of TB-infected possums occurred during the summer (November to January) with a slight peak in winter (July-August). The lowest average prevalence occurred during autumn. Juvenile possums are most likely to migrate during late summer and early autumn (Cowan and Clout, 2000). Thus, the two periods when possum control is likely to be most effective in reducing the TB risk are summer and autumn.

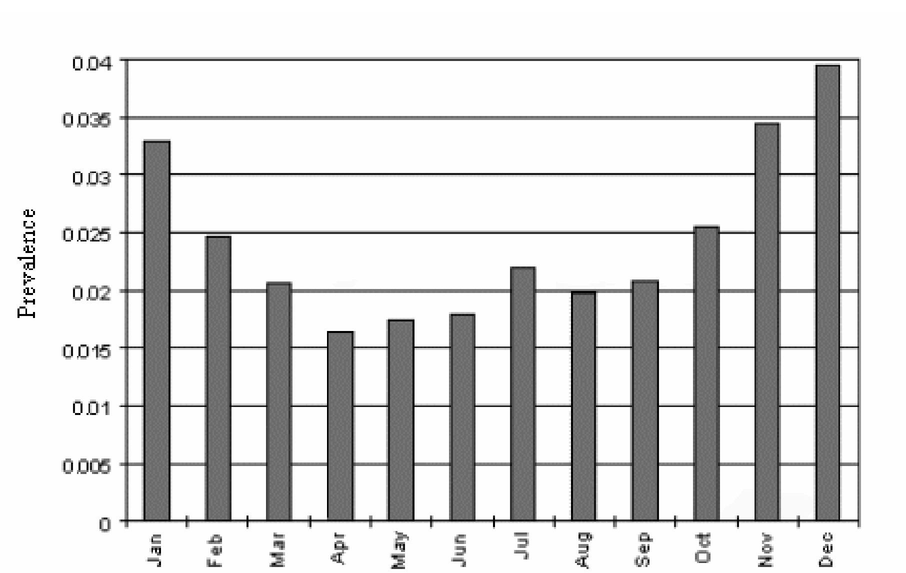


Figure 2. Average monthly point prevalence of TB in possums (data obtained from the longitudinal study in Castlepoint, Wairarapa) (Sauter-Louis, 2001).

Grazing management

The seasonality of possum deaths due to TB in the population studied at Castlepoint is shown in **Figure 3** (Sauter-Louis, 2001). This graph represents the mean across 7 years of the number of possums that died of TB during a month as a proportion of the population estimate for that month. The highest peak occurred during winter (July-August) with a smaller peak in summer (November to January). As tuberculous possums are most likely to show abnormal behaviour during the terminal stage of the disease, these dying possums pose the greatest risk for transmission of TB to cattle. If the direct contact between terminally ill tuberculous possums and livestock can be prevented or reduced, then the TB incidence in cattle or deer should also be reduced. There is some evidence that fencing cattle out of the area where tuberculous possums are denning will reduce the risk of cattle becoming infected. The construction of a fence which excluded cattle from the predominant possum denning area in the Castlepoint study site part was associated with a significant decline in incidence of TB in cattle (Paterson et al., 1995). Anecdotal reports from farmers indicate that large outbreaks of TB in cattle were more likely to occur in paddocks where cattle had access to possum denning habitat, but only smaller numbers of reactors occurred in paddocks where cattle were fenced out of such areas.

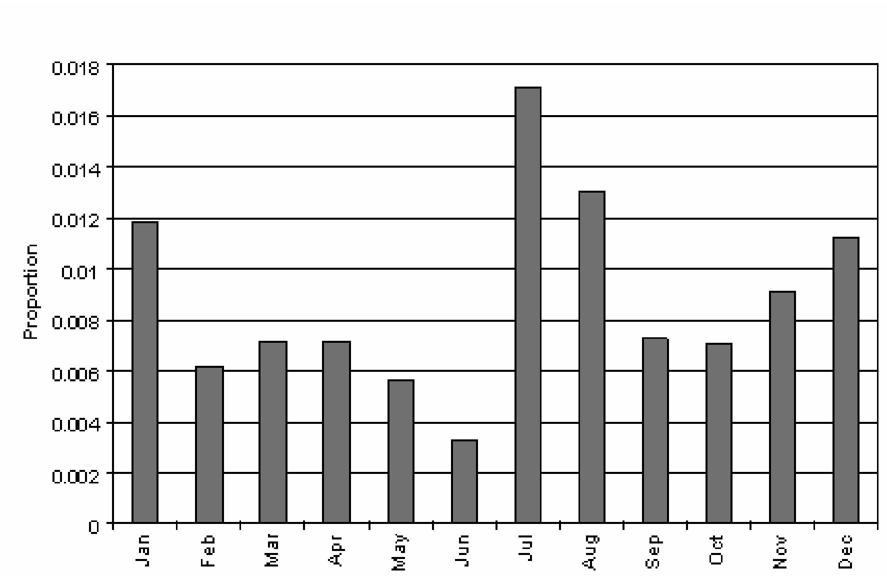


Figure 3. Proportion of possums dying from tuberculosis per month of population at risk (data obtained from the longitudinal study in Castlepoint, Wairarapa) (Sauter-Louis, 2001).

Adjusting the grazing rotation of cattle or deer so that animals are kept away from hot spot locations during the mid-winter and mid-summer months is likely to further reduce the risk of livestock becoming infected by TB possums. High-risk paddocks may be grazed with sheep during high-risk periods as they are less likely to investigate dying possums and thus less likely to become infected (Sauter and Morris, 1995). If the paddocks must be grazed with cattle or deer during the high-risk periods it is preferable to use lower value animals.

Resources for establishing farm management programmes

A farm map is an essential tool for designing an on-farm TB control programme. This facilitates the identification of high-risk areas on the farm and of probable hot spot locations. It is also useful to document such locations to direct focused possum control. Black and white aerial photographs with the farm boundary drawn in are available from Regional Council or many District Council offices. Many offices provide these free of charge to ratepayers, while others charge a small fee. Colour aerial photography is also available from many offices at variable prices.

A farm map with fence boundaries is extremely useful to design a grazing programme that avoids grazing near hot spots during high-risk times of the year. Regional Council offices will generally have such maps for a small number of farms for which soil conservation programmes have been developed. AgriQuality NZ is currently providing a service to draw digital farm maps with fences.

Satellite imagery is increasingly being used to develop digital land cover maps in areas of New Zealand. Again, Regional Councils are the major source of this data. There are two farm software packages available in New Zealand that include a geographic information system (GIS) component: Farm Tracker and Endeavour. These require farm maps with fence boundaries in digital format and are particularly useful for grazing management (Sauter-Louis, 2001). TB risk can be represented as a paddock variable and thus incorporated into a grazing programme that minimises the risk of contact between cattle or deer and TB possums during high-risk times of the year.

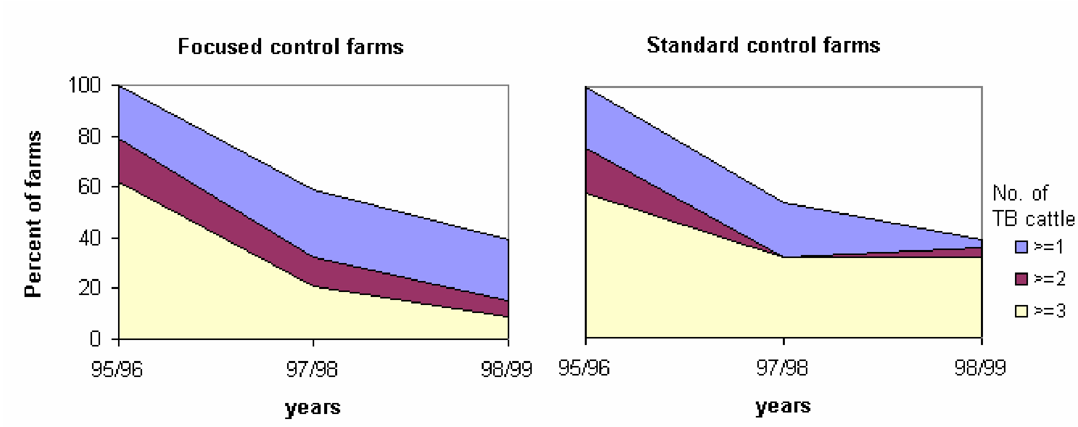
Effectiveness of individual farm control programmes

A study on the effectiveness of on-farm control programmes against possum-derived TB in cattle was conducted in the Wairarapa during 1997 – 1999 (Sauter-Louis, 2001). The pattern of TB incidence in cattle on approximately 30 farms that implemented a control programme was compared with that on an equal number of farms that did not implement such a programme. A total of 35 (18 programme and 17 non-programme) farms was located in areas where the standard Regional Council possum control programme was implemented, while 32 (16 programme and 16 non-programme) farms were located in areas with no Regional Council control. Each group included beef breeding, dry beef and dairy farms. The programme involved working with farmers to identify potential hot spot locations, followed by intensive possum control at these locations, and adjusted grazing management to keep cattle away from hot spots during the mid-summer and mid-winter months. A possum trapper was employed by the project to conduct intensive possum control on programme farms during the first two years of the study, following which farmers were responsible for this task in the third year. While the aim of the project was to undertake intensive possum control twice a year on each programme farm as described above, control was in fact conducted only once a year due to a lack of resources. Despite this reduced control effort, a beneficial effect was seen on certain programme farms as described below.

The on-farm programme resulted in a lower cattle TB incidence on beef breeding farms in the last two years of the project (1998/99) compared with the two years prior to the project (1995/96) (Table 1). However, there was no difference in performance between programme and non-programme dairy and dry beef farms (Sauter-Louis, 2001). The author hypothesised that this was due to beef breeding farms having more extensive habitat which supported possums compared with dairy and dry beef farms, thus more residual possums were likely to remain on these farms following standard Regional Council control. The additional targeted control applied through the on-farm programme was likely to reduce the residual possum population, particularly in high-risk areas, thus reducing the exposure of cattle to dying TB possums.

Focused control farms were significantly less likely to have multiple TB animals in the last two years of the project than standard control farms (**Figure 4**). A higher proportion of focused control farms (63%) than standard control farms (36%) came off movement control at the end of the project, and a lower proportion of focused control farms (9.1%) compared with standard control farms (21.4%) remained continuously infected throughout the three-year study period. While these latter two results were not statistically significant at the p=0.05 level, due to the small number of farms included in the study, they strongly indicate that focused control farms achieve more effective TB control than standard control farms.

Table 1. A comparison of the two-year cumulative incidence of TB in cattle within each herd type for programme and non-programme farms for the period before the project was implemented (1995/96) and for the second two years of the project (1998/99) (Sauter-Louis, 2001).



Group	Herd type	Cum. incidence 1995/96	Cum. incidence 1998/99	Percent reduction (98/99 vs 95/96)
Management programme	Beef breeding	0.0321 (n = 16)	0.0043 (n = 16)	86.6
	Dry beef	0.1714 (n = 8)	0.0030 (n = 7)	98.2
	Dairy	0.0254 (n = 10)	0.0024 (n = 10)	90.6
Standard control	Beef breeding	0.0497 (n = 17)	0.0308 (n = 14)	38.0
	Dry beef	0.0254 (n = 6)	0.0000 (n = 4)	100
	Dairy	0.0169 (n = 10)	0.0019 (n = 10)	88.8

Figure 4. Percent of focused and standard control farms with 1, 2, or >=3 TB cattle during the two-year period prior to the project and two-year periods during the project (Sauter-Louis, 2001).

The effect of the on-farm programme was evaluated for farms within areas that were receiving standard Regional Council control and those that weren't. This showed that the percent reduction in two-year TB incidence for the second two years of the project compared with the two years before the project was high for both programme and non-programme farms in areas receiving Regional Council control (**Table 2**). However, within areas that were not receiving Regional Council control the reduction in TB incidence on programme farms (92.5%) was markedly greater compared with non-programme farms (33.2%). This result is important as often farmers believe that they cannot have any worthwhile effect on TB control at farm level, without regional possum control (Sauter-Louis, 2001). These results suggest that this may not necessarily be the case and that individual farm programmes can have an impact in areas where there is no regional control.

Table 2. A comparison of the two-year cumulative incidence of TB in cattle on programme and non-programme farmswithin and outside areas that received Regional Council control, for the period before the project was implemented (1995/96) and for the second two years of the project (1998/99) (Sauter-Louis, 2001).

Group	Regional Council control	Cum incidence 1995/96	Cum incidence 1998/99	Percent reduction (98/99 vs 95/96)
Management	Yes	0.0166 (n=18)	0.0034 (n=18)	79.5
programme	No	0.0719 (n=16)	.0054 (n=15)	92.5
Standard	Yes	0.0179 (n=17)	0.0004 (n=15)	97.8
control	No	0.0346 (n=16)	0.0231 (n=13)	33.2

A comparison of the results of the focused farm study in the Wairarapa with one conducted nationally during 1995-1997 showed that focused control farms in both studies achieved a lower TB incidence and a higher proportion of farms off movement control (Sauter-Louis, 2001). However, the differences between focused and standard control farms were greater in the Wairarapa study. A factor believed to be critical to the success of the Wairarapa study, and hence to the success of on-farm TB management plans, was the close working relationship between the two-person project team and the farmers, involving frequent visits and/or phone calls to the farm. The relationship was further strengthened by one of the team conducting the focused possum control on the study farms throughout the first two years. This 'hands-on' approach is believed to have been more effective than using a large team with an advisory role only, as was the case in the national study.

Bibliography

Caley, P., Coleman, J.D. and Hickling, G.J. (2001). Habitat-related prevalence of macroscopic *Mycobacteriumm bovis* infection in brushtail possums (*Trichosurus vulpecula*), Hohonu Range, Westland, New Zealand. New Zealand Veterinary Journal 49 (3): 82 – 87.

Caley, P., Hone, L.J., and Cowan, P.E. (2001). The relationship between prevalence of *Mycobacterium bovis* infection in feral ferrets and possum abundance. New Zealand Veterinary Journal 49 (5): 195-200.

Cowan, P., and M. Clout. 2000. Possums on the move: activity patterns, home ranges, and dispersal. In T. L. Montague (Editor), The Brushtail possum: biology, impact and management of an introduced marsupial.p24-34. Manaaki Whenua Press, Landcare Research, P.O. Box 40 Lincoln 8152.

Hutchings, S. (2002). Veterinary practitioners and on-farm Tb management groups. Proceedings of the Deer Branch NZVA's annual conference, No. 19. Nelson, 15-17th May 2002.

Jackson, R. (1995). Transmission of tuberculosis (*Mycobacterium bovis*) by possums. Unpublished PhD thesis, Massey University, Palmerston North, New Zealand.

Lugton, I. W. (1997). The contribution of wild animals to the epidemiology of tuberculosis in New Zealand. Unpublished PhD thesis, Massey University, Palmerston North, New Zealand.

McKenzie, J. S. (1999). The use of habitat analysis in the control of wildlife tuberculosis in New Zealand. Unpublished PhD thesis, Massey University, Palmerston North, New Zealand.

Morris, R.S., Pfeiffer, D.U., and Jackson, R. (1994). The epidemiology of *Mycobacterium bovis* infections. Veterinary Microbiology 40 (1): 153-77.

Paterson, B. M. (1993). Behavioural patterns of possum and cattle which may facilitate the transmission of tuberculosis. Unpublished Master's thesis, Massey University, Palmerston North, New Zealand.

Paterson, B.M. and Morris, R.S. (1995). Interactions between beef cattle and simulated sedated possums on pasture. New Zealand Veterinary Journal 43 (7): 289-93.

Paterson, B.M., Morris, R.S., Weston, J., and Cowan, P. (1995). Foraging and denning pattern of brushtail possum and their possible relationships to contact with cattle and tuberculosis transmission. New Zealand Veterinary Journal 43 (7): 281-88.

Pfeiffer, D. U. (1994). The role of a wildlife reservoir in the epidemiology of bovine tuberculosis. Unpublished PhD thesis, Massey University, Palmerston North, New Zealand.

Sauter, C.M. and Morris, R.S. (1995). Behavioural studies on the potential for direct transmission of tuberculosis to farmed livestock from feral ferrets (*Mustela furo*) and possums (*Trichosurus vulpecula*). New Zealand Veterinary Journal 43 (7): 294-300.

Sauter-Louis, C. M. (2001). The effectiveness of on-farm control programmes against wildlife-derived bovine tuberculosis in New Zealand. Unpublished PhD thesis, Massey University.