THE EPIDEMIOLOGY OF BOVINE TUBERCULOSIS IN THE MACKENZIE BASIN

G.W. de Lisle, M. Hansen, G.F. Yates, D.M. Collins, Central Animal Health Laboratory, Wallaceville Animal Research Centre, P.O. Box 40-063, Upper Hutt.

R.W. MacKenzie, Ministry of Agriculture and Fisheries, Timaru

R. Walker, Ministry of Agriculture and Fisheries, Farlie

INTRODUCTION

Tuberculosis continues to be one of the most important infectious diseases of farmed deer in New Zealand. Previously little emphasis has been given to the role of farmed deer in the spread of Mycobacterium bovis to other hosts, such as cattle and feral/wild animals. In 1988, a project was started to describe the epidemiology of tuberculosis in the MacKenzie Basin. This region was chosen because it appeared to be a recently established area of endemic tuberculosis. In addition, there were indications that the epidemiology of tuberculosis in the MacKenzie Basin differed from that of other areas of endemic tuberculosis in New Zealand. There was a possibility that infected farmed deer were an important source of infection for other hosts, especially possums. Although infected possums had been found in the southern end of the MacKenzie Basin there were large areas where possum numbers were very low. The possibility existed that other feral/wild animals might be acting as a reservoir of tuberculosis.

MATERIALS AND METHODS

The boundary of the study area is shown in Figure 1. The farms in the MacKenzie Basin are very large by New Zealand standards and raise fine wool sheep and beef cattle. In 1990 the study area contained nine deer farms.

Skin testing and ancillary tuberculosis tests

In cattle the principal test was the caudal fold test using bovine purified protein derivative (PPD). The comparative skin test using avian and bovine PPDs was used on only a limited number of cattle. Although the cervical test was the principal test used in deer, the comparative skin test and lymphocyte transformation test were also extensively used for these animals.

Post mortem examinations

Suspect tuberculous lesions were examined using histology and culture. The culture procedure and the identification of mycobacterial isolates was carried out using the methods described by de Lisle and Havill (1985).

DNA restriction endonuclease analysis

DNA restriction endonuclease analyses of M.bovis were carried out by the method described by Collins and de Lisle (1985).

RESULTS

Description of tuberculosis in the MacKenzie Basin from skin testing data and post mortem examination of cull animals

The locations of the properties which had tuberculous livestock between 1980 and 1990 are shown in Figure 1.

(a) Cattle

Between 1980 and 1990 the policy on frequency of testing, class of stock to be tested and use of ancillary tests has altered. These changes occurred as a result of changes to the National tuberculosis control scheme and in reaction to the emerging tuberculosis problem in the MacKenzie Basin. Until 1982, breeding cattle herds in the MacKenzie Basin were tested biennially. Subsequently triennial testing was introduced in virtually all herds in South Canterbury/Mackenzie Basin, except those with a history of tuberculosis. In 1984 several tuberculous cattle were found on a newly infected herd. From 1984 onwards any animal that reacted to the caudal fold test in the Mackenzie Basin was designated a reactor. The modified interpretation of caudal fold skin test reactions was not used after 1984. The discovery in 1985 of 20 reactors (14 confirmed tuberculous) in a previously uninfected herd alerted Ministry of Agriculture and Fisheries field staff that there was an emerging tuberculosis problem. The results of skin testing of neighbouring herds and finding a tuberculous possum resulted in a further change in policy. The south eastern end of the Mackenzie Basin was declared endemic and a policy of annual testing was adopted. All stock 6 months of age and older in these herds were tested. No ancillary tests were used.

In 1987, further cases of tuberculosis were found on three more farms. In response to these findings, the endemic area was enlarged to include the area of the MacKenzie basin between Lake Pukaki, and Lake Tekapo to the Hakataramea pass. All stock and all herds in the declared endemic area were then subjected to at least an annual test. All animals which gave positive reactions to the test were slaughtered.

In 1988, further cases of tuberculosis were discovered in two herds in the south of the basin and in one at the northern end. As a result of these findings the whole of the MacKenzie Basin, excluding the area west of Lake Pukaki was declared endemic and all cattle herds were placed under annual test.

In 1989 the MacKenzie Basin was declared a Tuberculosis Special Control Area. The boundaries were drawn up and related to the number of indicator animals, current disease information and natural physical boundaries. Current tuberculosis strategies for the Mackenzie Basin are being reviewed annually.

The historical development of tuberculosis in cattle in the MacKenzie Basin from 1980 to 1990 is summarised in Table 1.

Figure 1. The boundary of the study area is indicated by a thickened line. Properties which had no cattle or farmed deer are denoted by horizontal lines. Farms which had either tuberculous cattle or deer are represented by diagonal shading. The locations of the deer farms are shown by D, the tuberculous possums by ●, and the tuberculous domestic cat by C .

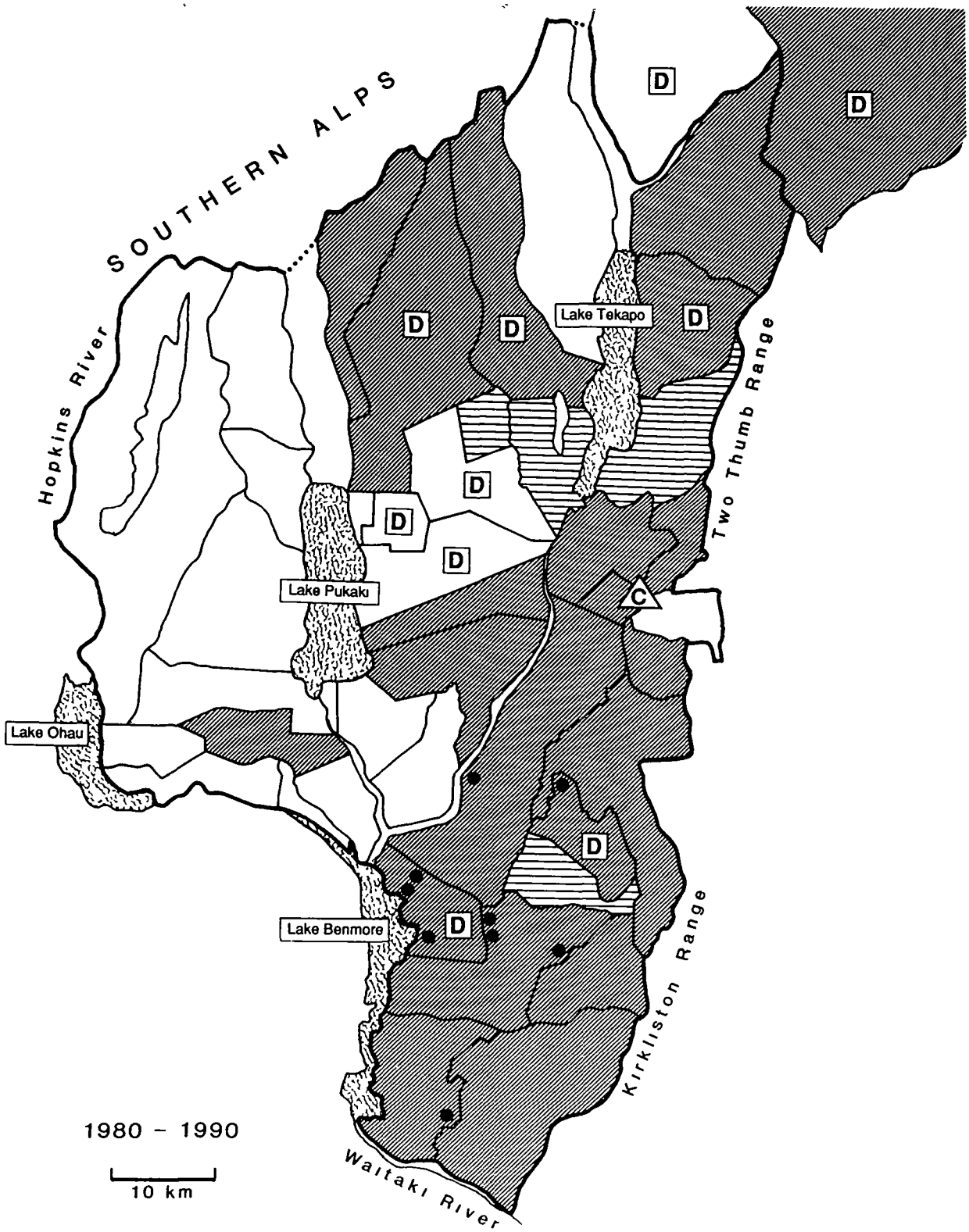

TABLE I

HISTORY OF TUBERCULOSIS IN CATTLE IN THE MACKENZIE BASIN

YEAR	No. TESTED	NO.CF+VE	NO.CCT+VE	NO.+VE HERDS / NO. HERDS TESTED (%)	NO. TB CULL	TOTAL TB	NO.+VE HERDS	NO. HERDS TB +VE FOR FIRST TIME
1980	2288	0	0	0/14 (0%)	1	1	1	1
1981	3780	1	0/1	0/14 (0%)	0	0	0	0
1982	1291	1	0/1	0/9 (0%)	0	0	0	0
1983	1173	1	0/1	0/7 (0%)	1	1	1	1
1984	2115	3	0/1	1/14 (7%)	0	2	1	1
1985	9674	27	0/2	4/16 (25%)	1	21	4	2
1986	9253	20	ND	4/10 (40%)	0	13	4	0
1987	10,451	33	ND	6/25 (24%)	1	18	6	3
1988	10,844	32	ND	9/25 (36%)	3	19	9	5
1989	11,440	27	ND	9/27 (33%)	1	16	9	1
1990*	4828	17	ND	4/18 (22%)	1	12	4	1
					TOTAL =	103		

* A number of the farms have yet to be tested in 1990.

CF = caudal fold skin test; CCT = comparative cervical skin test.

(b) Deer

In marked contrast to cattle, there was no compulsory tuberculosis control scheme for deer until 1990. A summary of the infection status of the nine deer farms in the MacKenzie Basin is given in Table 2. Small numbers of feral deer are present in the northern regions of the MacKenzie Basin but no M.bovis infection has ever been found in these animals..

(c) Possum

A total of nine tuberculous possums were found in the MacKenzie Basin between 1985 and 1989. Theses were all discovered in the south of the MacKenzie Basin (Fig. 1), the region of the study area containing the highest density of possums. In 1988 poisoning operations were begun to reduce the numbers of possums in this southern area.

(d) Rabbits

Large numbers of rabbits are present in the MacKenzie Basin. In 1989 post mortem examinations were carried out on over 1000 rabbits but no evidence of tuberculosis was found.

(e) Ferrets

In 1988 and 1989 a total of 47 ferrets and one stoat were examined for presence of tuberculosis. Although no evidence of tuberculosis was found in these animals, two tuberculous ferrets were discovered 25 kilometers below the southern boundary of the MacKenzie Basin. Ferrets on this property were observed eating a deer carcase.

(f) Cats

In 1988 and 1989 none of 15 feral cats examined was found to be infected with M.bovis. However, in 1988 tuberculosis associated with a middle ear infection was diagnosed in a domestic cat (Fig.1). This animal came from an area with very small numbers of possums.

(g) Miscellaneous

No evidence of tuberculosis was found on post mortem examination of various numbers of hawks, hedgehogs, pukekos, swans, ducks, oyster catchers, Canada geese, sheep, and hares.

DNA RESTRICTION ENDONUCLEASE ANALYSIS OF ISOLATES OF M.BOVIS.

A total of 95 isolates of M.bovis from 16 properties in the MacKenzie Basin were examined by DNA restriction endonuclease analysis. They have been classified into two major groups. One of these groups(C) has closely related restriction patterns, some of which are identical to those isolates of M.bovis from Central Otago and the area immediately south of the Waitaki river. The other group (W) consists of closely related isolates, some of which are identical to isolates which came from possums on the

TABLE II

HISTORY OF TUBERCULOSIS IN DEER IN MACKENZIE BASIN

PROPERTY	HERD SIZE	DATE TB FIRST DIAGNOSED	DATE FIRST COMPLETED WHOLE HERD TEST*	TOTAL NO OF TB	PRESENT TB STATUS
(1)	Large >3000	November 1986	December 1989	127	Infected MC
(2)	Medium 300-500	March 1987	March 1986	2	Clear MC
(3)	Large >500	June 1987	July 1986	37	Infected MC
(4)	Medium approx 170	July 1987	October 1988	27	Infected MC
(5)	Large 500-1000	December 1988	January 1990	11	Infected MC
(6)	Small 50-100	July 1989	July 1988	1	Infected MC
(7)	Large 500-1000	Not Diagnosed	Not yet completed	0	Infected MC
(8)	Small 50-100	" "	Sept. 1987	0	Accredited
(9)	Small approx 100	" "	July 1986	0	Clear MC
			Total =	205	

* Whole herd test as defined by the Official Deer Tuberculosis control scheme.

TABLE III

Number, source and DNA restriction type of M.bovis isolates for 5 properties where isolates were obtained from farmed and nonfarmed animals.

Property	Farmed animals			Non-farmed animals		
	No. typed	species	Restriction Type	No. typed	species	Restriction Type
(1)	2	Bovine	C1, C2	1	Feline	C1
(2)	13	Deer	C1	1	Possum	C1
(3)	2	Cattle	C1, C2	1	Posssum	C1
(4)	5	Cattle	C1, C4	1	Possum	C4
	32	Deer	C1, C3, C4, W1, W2, W4, W5, W6			
(5)	3	Cattle	C2, W2	2	Possum	C2, W2

West Coast of the South Island between 1982-4 (Collins et al., 1986) and more recently from the area of immediately south of the study area. The number, source and restriction type of the M.bovis isolates from the five properties where isolates were obtained from both farmed (cattle and deer) and nonfarmed (5 possums and a domestic cat) species are shown in Table III. Minor variations within the two major groups are denoted by a numeral.

Isolates of M.bovis from a large deer farm just outside the northern boundary of the study area (Fig. 1) had a restriction pattern which has only been seen in animals associated with this property.

DISCUSSION

Cattle testing information indicates that prior to 1980 the MacKenzie Basin was free of tuberculosis. Subsequently there was widespread dissemination of tuberculosis within this region. Given the results of skin testing, post mortem examinations of many animals, and typing of M.bovis isolates by DNA restriction endonuclease analysis it is possible to construct hypotheses on how bovine tuberculosis entered and spread within the MacKenzie Basin. The DNA restriction endonuclease analyses indicate that there are two major groups of M.bovis strains within the study area which is indicative of at least two separate introductions. One of these groups(W) contains some strains of M.bovis which have identical restriction fragment patterns to those found in possums from the West Coast of the South Island between 1982 and 1984 and more recently in an area to the south of the MacKenzie Basin. The introduction of M.bovis from the West Coast could have occurred by the live capture of infected feral deer from this region. Tuberculous feral deer have been found over a large area of the West Coast stretching from Karamea to south of Hokitika (de Lisle and Havill, 1985). One of the deer farms in the study area ran a live deer capture operation and retrieved deer from the West Coast.

The absence until 1990 of a compulsory scheme to control tuberculosis in farmed deer has been a considerable impediment to the control of tuberculosis in all susceptible hosts in the MacKenzie Basin. Deer have constituted over 67% of the infected farm animals in this region. Because generalised tuberculosis is more common in deer than cattle, and there were sometimes long delays in slaughtering deer which reacted to skin tests, it is highly likely that in the MacKenzie Basin infection has spread from infected farmed deer to possums.

The second group(C) of strains have fragment patterns which are the same or very similar to those present in isolates of M.bovis from the area south of the MacKenzie Basin. A review of the tuberculosis history of the cattle herds immediately south of the MacKenzie basin indicates there is a strong possibility that M.bovis infected feral/wild animals are present in this region. During the last 12 years, cases of tuberculosis have occurred in cattle on a significant proportion of properties that are

situated up to 30 kilometers outside the southern boundary of the study area. It is possible that this region contains infected possums and is known to contain infected feral pigs (C. Wakelin personal communication). It is highly likely that the Waitaki river does not form a physical boundary to prevent either the northern or southern spread of possums. However, the pattern of emergence of infection in the southern MacKenzie Basin is not consistent with the direct spread of infection from south of the Waitaki River. Further investigations are required to determine the extent of the distribution in Central Otago of the W group of strains of M.bovis. The introduction of infection by cattle or deer from south of the Waitaki river can not be absolutely discounted .

In the southern area of the study zone it is highly likely that infected possums have been the principal reservoir of infection. This contention is supported by finding the same restriction types of M.bovis in farmed animals and possums from the same property. However, the possum populations are very low in the northern regions of the MacKenzie Basin and it is unlikely they are responsible for spreading the infection there. The causes of the spread of tuberculosis in this northern area remains undetermined but they could include infected feral cats or ferrets. The MacKenzie Basin contains large numbers of rabbits which are part of the diet of both these species. An infected domestic cat has been found in the MacKenzie Basin (Fig 1) in an area which has very small numbers of possums. Although no infected ferrets have been found in the study area two infected animals have been located in an area 25 km south of the Waitaki river. It is thought that the ferrets became infected by eating a tuberculous deer carcase. A comprehensive survey has been planned to determine what role, if any, is played by cats or ferrets in spreading tuberculosis in the MacKenzie Basin.

An outbreak of tuberculosis in a large deer farm just outside the northern boundary(Fig.1) of the MacKenzie Basin indicated the possibility that infection was spreading out of the study area. However such spread does not appear to have occurred because when isolates of M.bovis from this farm were examined their restriction patterns were significantly different from those found in the MacKenzie Basin. Isolates with a similar restriction pattern have only been found in animals associated with this deer farm.

CONCLUSIONS

(1) Control of tuberculosis in the MacKenzie Basin has been hampered by the failure until 1990 to have deer under a compulsory test and slaughter programme. Successful control of tuberculosis requires an integrated programme which covers both cattle and deer.

(2) The presence of large numbers of infected deer on one property was the most likely source of infection for possums in the MacKenzie Basin.

(3) The spread of infection in the southern area of the MacKenzie Basin was probably due to infected possums.

(4) The cause of the spread of infection in the northern MacKenzie Basin is unknown but is unlikely to be possums because of their very low numbers in this region.

(5) The significance of ferrets and feral cats as sources of M.bovis needs to be determined.

(6) Examination of the DNA of isolates of M.bovis from the MacKenzie Basin showed there are two groups of strains. One of these groups has previously been found in animals in the West Coast of the South Island and more recently from an area south of the Waitaki river. The other major group has only been found in Central Otago and south of the Waitaki river. Thus, both the West Coast and the region south of the study area are possible sources of infection for the MacKenzie Basin.

(6) DNA examinations of isolates of M.bovis show that the outbreak of tuberculosis in deer just outside the northern boundary of the study area was not due to the spread of tuberculosis out of the MacKenzie Basin.

REFERENCES

Collins, D.M., de Lisle, G.W. (1985). DNA restriction endonuclease analysis of Mycobacterium bovis and other members of the tuberculosis complex. J. Clin. Micro. 21:562-4.

Collins, D.M., de Lisle, G.W., Gabric, D.M. (1986). Geographic distribution of restriction types of Mycobacterium bovis isolates from brush-tailed possums (Trichosurus vulpecula) in New Zealand. J. Hyg. Camb. 96:431-8.

de Lisle, G.W., Havill, P.F. (1985). Mycobacteria isolated from deer in New Zealand. N.Z. vet. J. 33:138-40.