

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**TWO STUDIES ON THE CONTROL OF WILDLIFE-
DERIVED TUBERCULOSIS:
FARMER VIEWS AND MODEL VALIDATION**

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE
OF MASTER OF VETERINARY STUDIES IN EPIDEMIOLOGY
AT MASSEY UNIVERSITY, PALMERSTON NORTH,
NEW ZEALAND.

RENE ANNE CORNER

2002

Printed by Massey University Printery, 2002

To obtain a copy of this thesis write to:

EpiCentre
Wool Building
Massey University
Palmerston North
New Zealand

Ph: +64 (0)6 350 5270

Fx: +64 (0)6 350 5716

E-mail: R.Corner@massey.ac.nz

Abstract

The two studies included in this thesis are part of a larger research programme evaluating tools to aid in the eradication of bovine tuberculosis (TB) from cattle in New Zealand. The first study was a survey of farmer's attitudes towards the National Pest Management Strategy (NPMS) and tuberculosis control. The second study validated the population component of PossPOP, a spatial stochastic simulation model of TB in a wild possum population.

A postal questionnaire survey identified variation of attitudes of 404 farmers in four regions of varying TB status within New Zealand. Farmers were stratified by region, enterprise type, area TB classification and herd TB status. Of the farmers contacted by telephone prior to sending out the questionnaire 91% agreed to participate in the study and 83% of these farmers returned a completed questionnaire. The questionnaire contained questions on farmer demographics, TB status, herd TB history, farm management practices and attitudes towards the control of TB. Farmers with infected herds were generally positive about the control program and believed that TB could be eradicated from their herds. A number of farmers were concerned about proposed changes to the NPMS, such as the implementation of direct payment of TB testing costs by farmers and removal of compensation for infected cattle. An important finding was that the majority of farmers were not aware that the Animal Health Board was in charge of the NPMS.

PossPOP was built using the first 22 months' data from a longitudinal study of a possum population run at Castlepoint in the lower North Island of New Zealand. Data from the remaining 9 years of the study was used set for model validation. PossPOP was validated by comparing age distribution, sex structure and the proportion of births, deaths and immigrations in the modelled population against the field population. There was general agreement between the model and the field population and also published population patterns. PossPOP produced a stable population over time at different densities, with similar temporal patterns to the field population. Emergent biological properties were examined, such as rate of population rebuilding after a major population cull, the removal of immigration from both populations and age specific mortality. The field population grew much more rapidly following a cull compared with the PossPOP population due to home range expansion of possums that were living on the periphery of the study site, which was not programmed into the model. These

results showed that while PossPOP models a small area, it reflects patterns of control over large areas making it a useful tool to evaluate large scale possum control strategies.

Acknowledgements

“Education is a valuable thing but every now and then it is wise to remember that anything worth knowing cannot be learned” Oscar Wilde

The above quote attracted my attention towards the end of writing this thesis. I would like to thank Leigh Corner and Laurie Lawler for their support and guidance in experiencing and discovering the things worth knowing in the last three years. The years have been an incredible growth period for me and I will always value this time. I would like to thank Dad, Leigh Corner, without whom this adventure would never had begun. It was he who encouraged me to become whatever I wanted to be and through whom I discovered science and wonder of the natural world. I would also like to thank Kara, Jon, Jeremy, Joshua and Matthew who needed me while I was away but understood my desire to complete this degree. Thank you for your support and encouragement to do this masters, the process was made easier knowing that while I missed you I would always be greeted with a big hug at the door upon my trips home.

The masters would not have been possible without Professor Roger Morris who gave me the opportunity to study at the EpiCentre. His support in this project has been greatly appreciated. I would also like to thank Jo McKenzie for all her help. Jo even though you were not officially one of my supervisors I appreciate all of your efforts more than I can express. I cannot imagine being at this point in writing my thesis if it had not been for your help, support and guidance.

There are many people that I have had the joy of working with at the EpiCentre and beyond over the last 3 years. To Naomi Boxall, Carola Sauter-Louis and Nina Kung thank you for being the best office buddies a girl could want. I would also like to thank the EpiCentre social club, Kathy, Jo, Solis, Simon, Daniel, Richard and Deb thank you for all the Friday night de-briefing sessions at Icons.

I owe a great deal of thanks to the Animal Health Board who funded this project. I would like to thank the staff of the Animal Health Board Paul Livingstone, Victoria Anderson and Jeanie McInnes for your willingness to answer my many and varied questions. I would also like to thank staff from AgriQuality: Robert Sanson, Catherine Cameron and Terry Ryan for their various help with obtaining information. Finally I would like to thank “my farmers” who participated in the survey, without your time and input this investigation would not have been possible.

Table of Contents

ABSTRACT	I
ACKNOWLEDGEMENTS	III
TABLE OF CONTENTS	V
LIST OF FIGURES	VII
LIST OF TABLES	XI
INTRODUCTION	1
<i>Study Objectives</i>	6
REFERENCE LIST	6
CHAPTER 1 A REVIEW OF THE LITERATURE	9
SECTION 1 THE STRUCTURE AND MANAGEMENT OF THE NEW ZEALAND TUBERCULOSIS CONTROL PROGRAMME: AN OVERVIEW	11
INTRODUCTION	13
CONTROL OF TB AT THE LEVEL OF INDIVIDUAL ANIMALS	13
<i>Tests for tuberculosis in cattle</i>	14
<i>Tests for tuberculosis in deer</i>	15
<i>Tuberculosis classification of livestock and consequences</i>	15
CONTROL OF TB AT THE HERD LEVEL	16
CONTROL OF TB AT THE REGIONAL LEVEL	20
VECTOR CONTROL	23
NPMS MANAGEMENT STRUCTURE	26
<i>Funding of the NPMS</i>	29
THE RESPONSIBILITY OF FARMERS WITHIN THE NATIONAL PEST MANAGEMENT STRATEGY	30
SECTION 2 THE DESIGN AND USE OF QUESTIONNAIRES: A LITERATURE REVIEW	31
INTRODUCTION	33
QUESTIONNAIRE DESIGN	33
TYPES OF QUESTIONNAIRES	34
SOURCES OF ERROR IN SURVEYS	35
ETHICS OF SURVEYS	37
DATA QUALITY CONTROL	38
SECTION 3 AN INTRODUCTION TO THE POSSPOP SIMULATION MODEL AND PROCEDURES APPLICABLE TO ITS VALIDATION	39
MODELS	41
<i>Simulation Modelling</i>	41
<i>Model validation</i>	46
MODELS OF TUBERCULOSIS	49
POSSPOP	50
<i>Description of PossPOP</i>	50
<i>Temporal and spatial scales</i>	51
<i>Structure of PossPOP</i>	52
REFERENCE LIST	55
CHAPTER 2 ATTITUDES OF NEW ZEALAND FARMERS TO BOVINE TUBERCULOSIS AND THE IMPLICATIONS FOR CONTROL STRATEGIES	63
INTRODUCTION	65
METHODS	65
<i>Survey</i>	65
<i>Analysis</i>	67
<i>Explanation of terms</i>	68
RESULTS	68
<i>Demographic information (Questions 1-8)</i>	69
<i>Farmer Attitudes</i>	73

DISCUSSION.....	91
ACKNOWLEDGMENTS.....	94
REFERENCE LIST.....	94
CHAPTER 3 VALIDATION OF A DISCRETE STOCHASTIC SIMULATION MODEL OF BOVINE TUBERCULOSIS IN WILD POSSUM POPULATIONS.....	95
INTRODUCTION.....	97
MATERIALS AND METHODS.....	98
<i>Simulated data set.....</i>	98
<i>Field data set.....</i>	103
<i>Validation of the model.....</i>	104
RESULTS.....	109
<i>Optimum number of iterations.....</i>	109
<i>Stability of the simulated population at different densities.....</i>	111
<i>Comparison of PossPOP population pattern with Castlepoint.....</i>	112
<i>Population structure.....</i>	117
<i>Population dynamics.....</i>	123
DISCUSSION.....	128
<i>Population stability and dynamics.....</i>	128
<i>Population re-building after a cull.....</i>	130
<i>Population structure.....</i>	131
<i>Age distribution of dead possums.....</i>	132
<i>Optimum number of iterations.....</i>	132
REFERENCE LIST.....	133
CHAPTER 4 GENERAL DISCUSSION.....	135
ATTITUDES OF NEW ZEALAND FARMERS TO BOVINE TUBERCULOSIS.....	137
VALIDATION OF POSSPOP, A STOCHASTIC SIMULATION MODEL.....	139
DIRECTIONS FOR FURTHER RESEARCH.....	142
REFERENCE LIST.....	143
APPENDIX 1 – QUESTIONNAIRE.....	145

List of Figures

Figure 1. Structure of herd classification illustrating the transition from Infected to Clear (Adapted from: Animal Health Board Inc, 1995).....	18
Figure 2. The distribution of vector risk, fringe, surveillance and vector free areas in New Zealand in February 2001	20
Figure 3. TB vector risk and vector free areas with corresponding subdivisions (Reproduced from: Animal Health Board Inc, 1995).....	22
Figure 4. Diagram of the management structure of the NPMS for both policy and operations (Adapted from: Animal Health Board Inc, 1995b).....	28
Figure 5. Funding structure of the National Pest Management Strategy (Animal Health Board Inc, 1995).....	29
Figure 6. Classification method of process epidemiological models (Adapted from: “Hurd and Kaneene, 1993).....	43
Figure 7. Process of model development (Reproduced from: “Fishwick, 1995)	44
Figure 8. Five stage approach to model development (Adapted from: “Anderson, 1974)	45
Figure 9. Illustration of the PossPOP program interface	51
Figure 10. Districts sampled for the postal questionnaire.....	66
Figure 11. Summary of the numbers of farmers, who were selected, agreed to participate and responded to the postal survey in each TB status within each district.....	68
Figure 12. Percentage of returned questionnaires for each district by TB status	70
Figure 13. Percentage of each enterprise type stratified by TB status.....	70
Figure 14. Frequency distribution of farmer age groups	73
Figure 15. The distribution of respondent’s relationship to the property	73
Figure 16. Distribution of reasons chosen to explain the factors contributing to TB infection of a herd	74
Figure 17. The importance of TB eradication to respondents with infected herds.....	75
Figure 18. Distribution of responses from infected farmers on the likely success of TB eradication from their herd.....	76
Figure 19. Factors that infected farmers believe are hindering eradication of TB from herds	77
Figure 20. Groups and institutions perceived as being responsible for TB eradication and the average ranking for that group	78
Figure 21. Types of assistance respondents would expect to receive from each institution if asked to carry out their own TB control	80
Figure 22. Percentage of themes for reasons for response on strictness of cattle movement ..	82
Figure 23. Percentage of responses on the effect of the removal of compensation on progress of TB eradication, by herd type.	83
Figure 24. Frequency of themes for each response to removal of compensation.....	84
Figure 25. Responses as to whether TB would be eradicated faster if farmers paid their own TB testing costs	85
Figure 26. Percentage of responses as to whether TB would be eradicated more quickly if cattle farmers paid for TB testing directly grouped by enterprise type	85

Figure 27. Percentage of written response themes stratified by their initial response on the effect of direct payment for TB testing	87
Figure 28. Distribution of responses to question on farmer efforts to eradicate TB	88
Figure 29. Methods for the national eradication of TB	89
Figure 30. Response themes for incentives to aid TB eradication by area classification.....	90
Figure 31. Percentage of written response themes on how farmers see TB being eradicated from New Zealand by enterprise type.	91
Figure 32. An aerial photograph of the 24-hectare Castlepoint study site where the longitudinal study of TB in possums was conducted (1989-2000)	104
Figure 33. Monthly population means for the simulated high-density population using 5, 10 and 15 iterations	109
Figure 34. Monthly population means before the cull for the simulated high-density population using 5, 10 and 15 iterations (January 01 to January 05)	110
Figure 35. Monthly population means after the cull for the simulated high-density population using 5, 10 and 15 iterations (February 05 to December 10).....	110
Figure 36. The 95% confidence interval range (Upper CI – lower CI) for the mean population each month using 5, 10 and 15 iterations for the high-density population.	111
Figure 37. Monthly population size of the moderate and high-density populations over a 10-year simulation period.	112
Figure 38. Jolly-Seber estimate of the Castlepoint population over time. * The population estimates begin in May 01 as no population estimate is produced by the Jolly-Seber estimation for the first trapping in April 01.....	113
Figure 39. The high-density PossPOP population showing the 95% population cull.....	114
Figure 40. The percent population change each month for the PossPOP and Castlepoint populations.....	115
Figure 41. Percentage growth per month for the simulated and Castlepoint populations after each population was culled by 95% and 99% respectively. * The growth rate in the first month after the cull (November 07 – December 07) in the Castlepoint population was 1256% (3- 40 possums) was not included in the chart as it obscured the differences seen in the remaining months.....	116
Figure 42. A comparison of the percentage of females in the total population for moderate and high-density populations.....	117
Figure 43. The mean monthly percentage of females in the Castlepoint population per year.	118
Figure 44. Mean percentage of females in the simulated high-density population stratified by age.	119
Figure 45. Mean monthly percentage of juveniles per year in the high and moderate-density populations over a 10-year simulation.....	120
Figure 46. A comparison of the percentage of males that are juvenile for moderate and high-density populations.....	121
Figure 47. A comparison of the percentage of females that were juvenile in the moderate and high-density populations.....	122
Figure 48. A comparison of the monthly conception rate in the high-density simulated and Castlepoint populations	123

Figure 49. The difference in the monthly conception rates of the high-density simulated population minus the Castlepoint population.	124
Figure 50. A comparison of the monthly immigration rate in the high-density simulated and Castlepoint populations.....	125
Figure 51. A comparison of the percentage of disappearances for the simulated and Castlepoint populations. * As a possum in the Castlepoint population was classified as having disappeared if it wasn't trapped for 4 months, no disappearance dates after the cull in October and November in year 6 was available until June of year 7.	126
Figure 52. Distribution of age at death for the high density simulated population.	127
Figure 53. Comparison of the simulated population with and without immigration.	128

List of Tables

TABLE 1. DEFINITION OF MAINTENANCE, SPILLOVER AND RESERVOIR HOSTS (MORRIS AND PFEIFFER, 1995).....	4
TABLE 2. CRITERIA FOR THE TUBERCULOSIS CLASSIFICATION OF LIVESTOCK (ANIMAL HEALTH BOARD INC, 1995).....	14
TABLE 3. TESTING FREQUENCY BY HERD STATUS AND AREA CLASSIFICATION (ANIMAL HEALTH BOARD, 2001G).....	23
TABLE 4. ADVANTAGES AND DISADVANTAGES OF POISONS USED FOR VECTOR CONTROL (EASON ET AL., 2000).....	25
TABLE 5. ADVANTAGES AND DISADVANTAGES OF TRAPPING METHODS USED FOR VECTOR CONTROL (MONTAGUE AND WARBURTON, 2000).....	26
TABLE 6. TYPES OF BIASES THAT ARISE IN SURVEYS (DUOBA AND MAINDONALD, 1988).....	37
TABLE 7. NUMBER OF RESPONDENTS BY TB STATUS, REGION AND ENTERPRISE TYPE.....	69
TABLE 8. PERCENTAGES OF ENTERPRISE TYPES WITHIN EACH REGION.....	71
TABLE 9. MEDIAN AND RANGE OF "TOTAL EFFECTIVE FARM SIZE" AND NUMBER OF WORKERS BOTH FULL TIME AND PART TIME STRATIFIED BY TB STATUS.....	72
TABLE 10. THEMES FOR CATEGORISING RESPONSES TO FACTORS HINDERING TB ERADICATION FROM INFECTED HERDS.....	76
TABLE 11. THEMES FOR CATEGORISING RESPONSES ON FORMS OF ASSISTANCE FOR FARMER CONDUCTED TB CONTROL MEASURES.....	79
TABLE 12. MOST COMMON RESPONSE(S) TO QUESTION ON MOVEMENT CONTROL BY TB STATUS AND REGION.....	81
TABLE 13. THEMES FOR CATEGORISING RESPONSES ON REASONS FOR THEIR RESPONSE ON STRICTNESS OF CATTLE MOVEMENT CONTROL.....	81
TABLE 14. THEMES FOR CATEGORISING RESPONSES ON REASONS FOR THEIR RESPONSE ON REMOVAL OF COMPENSATION.....	83
TABLE 15. THEMES FOR CATEGORISING RESPONSES ON DIRECT PAYMENT OF CATTLE TB TESTING.....	86
TABLE 16 . THEMES FOR CATEGORISING RESPONSES ON THE EFFORT INDIVIDUAL FARMERS COULD PLAY IN TB CONTROL.....	87
TABLE 17. THEMES FOR CATEGORISING RESPONSES ON HOW FARMERS SEE TB BEING ERADICATED FROM NEW ZEALAND.....	89
TABLE 18. THEMES FOR CATEGORISING RESPONSES ON INCENTIVES FARMERS BELIEVE WILL AID IN TB ERADICATION.....	90
TABLE 19. LIST OF MECHANISMS AND PARAMETERS THAT OPERATE ON THE POPULATION DYNAMICS OF POSSPOP (COCHRANE, 1998).....	99
TABLE 20. MONTHLY PARAMETER SETTINGS FOR AN "AVERAGE YEAR" FROM THE PARAMETER FILE SINK12_J25 THAT VARY THROUGHOUT THE YEAR.....	100
TABLE 21. GENERAL PARAMETER SETTINGS FOR PARAMETER FILE SINK12_J25 APPLIED CONSISTENTLY THROUGHOUT THE YEAR.....	101
TABLE 22. SETTINGS FOR THE POSSPOP SIMULATION RUNS.....	101
TABLE 23. VARIABLES INCLUDED IN THE "RESULTS" AND "SURVIVAL" TABLES.....	102