Epidemiological studies to inform control strategies for paratuberculosis in farmed deer

A thesis presented
in partial fulfilment of the requirements
for the degree of Doctor of Philosophy
at Massey University

Lesley Stringer

Institute of Veterinary, Animal and Biomedical Sciences
Massey University
Palmerston North, New Zealand

2010
(Submitted December 10, 2010)

Institute of Veterinary, Animal and Biomedical Sciences

Massey University

Palmerston North, New Zealand

2010

Abstract

Paratuberculosis, caused by *Mycobacterium avium* subsp. *paratuberculosis* (MAP), occurs in a range of ruminant species, and has been diagnosed in wild and domesticated deer worldwide. The disease process in other ruminants is chronic and fatal, with the highest clinical disease incidence generally seen in older animals. However, in farmed deer, disease incidence is highest in young animals, occurring as an acute syndrome in deer as young as eight months of age. The deer industry in New Zealand is concerned about the on-farm impact of paratuberculosis, and the consequences for the venison market should MAP be classified as a zoonosis. Research is thus directed at investigating tools for paratuberculosis control, to reduce the threat to the industry.

The aim of the research presented in this thesis was to provide epidemiological evidence that can be used to inform strategy, at industry and farm-level, for control of paratuberculosis in deer.

A survey of the deer slaughter population established a baseline prevalence of MAP infection, against which the effects of control initiatives can be measured. Infection was widespread in individuals (45%) and herds (59%), suggesting control rather than eradication as the goal of any industry programme.

On-farm disease control was investigated in a randomised controlled trial of vaccine efficacy in young naturally-infected deer. Vaccination reduced the incidence of clinical disease and subclinical pathology; no significant effect on mean production parameters was seen. There was no effect of vaccination on faecal MAP excretion, indicating vaccination may not reduce infection prevalence. Vaccinated deer had an increased risk of testing positively to diagnostic screening tests for bovine tuberculosis. Non-specificity was resolved by ancillary testing, but such tests come at an increased financial and test sensitivity cost.

Paratuberculosis control at the industry level may involve schemes to classify herd infection status. For this purpose, the sensitivity and specificity of individual faecal culture and

an IgG1 ELISA (Paralisa) to detect young deer infected with MAP was estimated using Bayesian latent class analysis. Paralisa and faecal culture had sensitivity of 19% and 77%, and specificity of 94% and 99%, respectively. Improved diagnostics are therefore needed if herd infection status is to be classified in a sensitive, specific, cost-effective and timely system.

The studies contribute to knowledge on different aspects of paratuberculosis control in the New Zealand farmed deer population, providing an evidence base for informed decision-making at farm and industry level.

Acknowledgements

I arrived at Massey University with high hopes of expanding and enhancing my epidemiological skills while doing useful applied animal health research. On both counts my expectations were met in full and I sincerely thank my three supervisors Peter Wilson, Cord Heuer and Colin Mackintosh for guiding me, and for being so generous with their time and in sharing their knowledge and expertise. I particularly appreciated the diversity of opinion that would come out of our group discussions and felt I benefited hugely from the different perspective that each of you brought to scientific debate.

It has been a privilege to work with and for New Zealand deer farmers in some of the most beautiful places on earth, and I thank all who gave freely of their time, labour and patience during the vaccine trial. Thanks, too, to the vets who helped with recruitment and on-farm diagnosis. Noel Beatson, especially, put a huge personal effort into the field work of the trial, giving this deer-farming novice the benefit of his experience and knowledge of deer and (even more importantly) deer farmers. Thanks also to Geoff de Lisle and Gary Yates at Wallaceville for advice and diagnostic support that helped me get the best results from the projects and to all at DRL, Otago University for getting me started on PCR methodology.

A long list of Massey University and visiting students helped with on-farm and abattoir work and I couldn't have managed without Jan-Willem, Art, Helena, Jorien, Cristobal, Paulina, Rayon, Martin and Anou and not forgetting Megan, who was unfortunate enough to arrive in New Zealand on holiday just in time to help with the faecal sampling. Abattoir management and staff could not have been more helpful during both the vaccine trial and prevalence study, and I thank too the plant meat inspectors and vets for their enthusiastic help with sample and data collection. A special mention to everyone at NZVP and the 'poo-pushing' team who helped with sample processing at Massey, led first by Saskia and then Neville. Cristobal, I will always associate your music collection with the aroma of fresh animal faeces.

It has been a delight to work with statisticians from Massey, UC Davis and Warwick University - Geoff Jones, Alasdair Noble, Wes Johnson and Chris Jewell. Thanks to all of you for sharing your expertise, and for managing to enthuse me about Bayesian statistics. Everyone at the EpiCentre has helped me in some way, and I especially appreciate Wendy and Christine, not just for administrative support and proof-reading but for providing laughs as well as sympathetic ears. Thanks also to Debbie Leader, without whose saintly patience this document would never have been compiled. I'm grateful to Mark and Naomi for impromptu statistical discussions, which my "quick questions" invariably turned into. Jackie, thank you for all your advice, both professional and personal, and for helping me to hold on to my sense of humour when the going got tough. To Jaimie, my PhD-buddy, JD-mentor, giver and receiver of regular rants: I thank you for your friendship, kindness, humour, moral support and for your selfless generosity in passing the test validation project on to me!

I gratefully acknowledge the support of Massey University Doctoral Research and New Zealand International Doctoral Research scholarships, without which I could not have undertaken this study. To the many and varied residents of The Commune and Manawatu Street - it was most interesting to return to student flatting after a break of 20 years, but I have thoroughly enjoyed the experience. Anou, we have as many similarities as differences and I thank you for expanding my world view.

Finally, I thank the most important people- my parents and partner, David, who have supported me in every way in my various endeavours. To the relief of you all, my student days are finally now over.

Nomenclature

AHB	Animal Health Board
CCT	Comparative cervical test
CI	Confidence/credible interval
DINZ	Deer Industry New Zealand
ETB	ELISA for bovine tuberculosis
GLM	Generalised linear model
IFC	Individual faecal culture
JD	Johne's disease
JML	Johne's Management Limited
LSS	Lesion severity score
MAP	*Mycobacerium avium* subsp. *paratuberculosis*
MCMC	Markov chain Monte Carlo
MCT	Mid-cervical test
OD	Optical density
OIE	World Organisation for Animal Health
PCR	Polymerase chain reaction
TB	Tuberculosis

List of Publications

Goodwin-Ray K, Stringer LA, Wilson PR, Heuer C, Glossop JC. Vaccination of deer for Johne's disease with Silirum: Safety, dose and tuberculosis test cross - reactivity. In: *Proceedings of a Deer Course for Veterinarians, Deer Branch of the New Zealand Veterinary Association*. Pp 44-9, 2008.

Stringer LA, Heuer C, Mackintosh CG, Wilson PR. Silirum vaccine in the control of Johne's disease in young farmed deer, preliminary results from a field efficacy trial. In: *Proceedings of a Deer Course for Veterinarians, Deer Branch of the New Zealand Veterinary Association*. Pp 57-61, 2009.

Stringer LA, Wilson PR, Heuer C, Mackintosh CG, Glossop JC, Verdugo C. Isolation of *Mycobacterium avium* subsp. *paratuberculosis* from grossly normal mesenteric lymph nodes of slaughter deer, preliminary results from a nationwide prevalence study. In: *Proceedings of a Deer Course for Veterinarians, Deer Branch of the New Zealand Veterinary Association*. Pp 67-71, 2009.

Wilson PR, Mackintosh CG, Heuer C, Hunnam JC, Stringer LA. Paratuberculosis in deer: what we know, what we think we know and what we don't know. In: *Proceedings of a Deer Course for Veterinarians, Deer Branch of the New Zealand Veterinary Association*. Pp 45-50, 2009.

Stringer LA, Wilson PR, Heuer C, Mackintosh CG. The effect of Silirum vaccine on subclinical Johne's Disease in young farmed deer (*Cervus elpahus*) - preliminary results from a randomised controlled trial. In: *Proceedings of a Deer Course for Veterinarians, Deer Branch of the New Zealand Veterinary Association*. Pp 53-5, 2010.

Contents

List of Figures

List of Tables

Preface

There is a theory which states that if ever anybody discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable. There is another theory which states that this has already happened.

Douglas Adams