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The Biology of *Avipoxvirus* in New Zealand Avifauna

A thesis presented in partial fulfillment
of the requirements for the degree of

Doctor of Philosophy in Veterinary Pathology

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To My Beloved Family

사랑하는 가족에게 이 논문을 바칩니다

ABSTRACT

Avipoxvirus (APV) infection is a highly contagious disease of birds which is comparable to poxvirus infections in various mammalian species, including smallpox in humans. The infection has been reported in more than 200 bird species, affecting both domesticated and free-ranging birds around the world. The disease is associated with economic loss in the poultry industry and is implicated with the decline in biodiversity in free-ranging birds, particularly in island ecosystems. This study was the first investigation into APV infection in New Zealand free-ranging birds. The initial focus of this study was the phylogenetic analysis of APV in New Zealand. Avipoxvirus antibody was then detected using enzyme-linked immunosorbent assay (ELISA) in several introduced species and an endemic passerine species in New Zealand. The pathogenicity of two major APV strains isolated from New Zealand birds was evaluated and the safety and efficacy of a commercial fowlpox (FWPV) vaccine was investigated in a model passerine species.

This study confirms that various New Zealand birds including endangered species are susceptible to APV infection and that at least three different strains of APV are present in New Zealand, with overlaps in the geographic distributions between different strains. The results suggest that APV had been introduced to New Zealand through avian hosts, insect vectors or human intervention such as poultry vaccination. A high seroprevalence to APV has been observed in introduced and an endemic bird species in New Zealand, confirming that the virus is well established. A significant relationship between birds seropositive to APV and the ones positive to *Plasmodium* spp. has also been observed, both of which are known to be pathogens responsible for dramatic declines in island bird populations. Two major New Zealand APV strains isolated from clinical cases were pathogenic in Zebra finches (*Taeniopygia guttata*), which we used as

a model passerine species. A commercial FWPV vaccine was safe and effective in our model species against New Zealand APV isolates and I conclude that vaccination of native passerine birds using the FWPV vaccine could be an effective tool to reduce APV mortality, particularly in endangered species.

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THESIS STRUCTURE AND FORMAT

This thesis is written as a series of seven interrelated chapters, three of which (Chapters two, three and four) have been published in peer reviewed journals (Ha *et al.* 2011; Ha *et al.* 2012b; Ha *et al.* 2012a) and one of which (Chapter six) has been submitted to a peer reviewed journal.

Chapter one: Avipoxvirus – General Introduction introduces the main subject of my thesis by discussing the current knowledge on avipoxvirus (APV) in birds and reviewing the literature on various aspects of APV infecting domestic and wild birds. At the end of this first chapter, a brief summary of the specific aims of this thesis is presented.

Chapter two: The Phylogenetic Analysis of Avipoxvirus in New Zealand has been published in *Veterinary Microbiology* (Ha HJ, Howe L, Alley M, Gartrell B. 150, 80-7, 2011) and describes the results of the first phylogenetic analysis of APV in New Zealand.

Chapter three: Avipoxvirus Infections in Brown Kiwi (*Apteryx mantelli*) has been published in *New Zealand Veterinary Journal* (Ha HJ, Alley MR, Howe L, Castro I, Gartrell B. DOI:10.1080/00480169.2012.700629, 2012) and describes APV infections identified in two endemic brown kiwi. Not only it is the first APV reported in kiwi populations, it is the first viral disease documented.

Chapter four: The Seroprevalence of Avipoxvirus and Its Association with Avian Malaria (*Plasmodium* spp.) Infection in Introduced Passerine Birds in the Southern Regions of the North Island of New Zealand has been published in *Avian Diseases* (Ha HJ, Banda M, Alley M, Howe L, Gartrell BD. DOI: 10.1637/10285-061912-ResNote. 1, 2012).

Chapter five: The Detection of Avipoxvirus Antibody in North Island Robins (*Petroica australis longipes*) Demonstrates the Endemic Status of Avipoxvirus in Birds on an Island Refuge Used for Conservation describes the results of the first attempt to screen for APV antibody. This chapter further suggests the possibility of APV antibody screening in the event of translocation of endangered species.

Chapter six: Evaluation of the Pathogenicity of Avipoxvirus Strains Isolated from Wild Birds in New Zealand and the Efficacy of a Fowlpox Vaccine in Passerines has been submitted to Veterinary Microbiology (Ha HJ, Howe L, Alley M, Gartrell B.) and describes the results of challenge and vaccination studies carried out in a model passerine species.

Chapter seven: General Discussion summarises all information and puts it into context. The relevance of my findings is discussed and future research directions are suggested.

References: All references are listed at the end of the thesis to minimise repetition. All literature cited is consistent with the format used for the scientific journal: *New Zealand Veterinary Journal*.

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