The ecology of *Aspergillus fumigatus* and implications for wildlife conservation in modified environments

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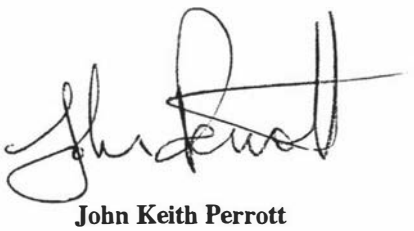
Declaration of Originality

This thesis represents the original work of the author, except where otherwise acknowledged. It has not been submitted previously for a degree at any university



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Abstract

This thesis outlines my research since 1998 into inter-trophic interactions between pathogenic fungi, insects, birds, and the environment. Chapter One is a stand-alone investigation into fungal diseases associated with native cicadas on Mokoia Island (Lake Rotorua) and the Eastwoodhill Arboretum (Gisborne). Chapters Two through Four are specifically concerned with the natural occurrence of the pathogenic fungus *Aspergillus fumigatus* and its connection to hihi (or stitchbird) on Little Barrier Island (northern Hauraki Gulf), Mokoia Island, Tiritiri Matangi Island (Hauraki Gulf), and the Mt Bruce Wildlife Centre (near Masterton).

The hihi (*Notiomystis cincta*) is a small (i.e., starling sized) cavity-nesting honeyeater endemic to New Zealand. Following European colonisation, hihi became extinct everywhere except on Little Barrier Island, making the future of this species very uncertain. In response to this situation there have been several translocations of hihi to Hen, Cuvier, Kapiti, Mokoia and Tiritiri Matangi Islands from 1980 to 1996. While hihi on Tiritiri Matangi seem to be progressing well with intensive management, all previous translocations to other islands have failed to establish self-sustaining populations. The main hypotheses given to explain these failures are insufficient year-round supply of nectar and fruit, and lack of suitable nesting cavities.

Hihi were translocated to Mokoia Island in September 1994 with nest boxes provided. However, like past translocations, hihi have continued to decline on the island with high annual mortality rates above 50%. It is not clear what factors are contributing to this high mortality rate. My MSc studies carried out on Mokoia Island during 1994-1997 demonstrated that hihi had a good year-round supply of food, and were not dying as a result of starvation. Subsequent post-mortem examinations by Professor Alley of sick and dead hihi from Mokoia from 1995-1997 has revealed that the fungal disease aspergillosis, caused by *Aspergillus fumigatus*, is the most common cause of death among those birds. In addition, captive hihi at the Mt Bruce Wildlife Centre also suffer high rates of aspergillosis, and there is presently concern regarding the susceptibility of hihi to this fungal disease. This study suggests also that past hihi translocations have failed due, in part, to birds being exposed to elevated levels of disease-causing microorganisms.

Aspergillus fumigatus is an ubiquitous fungus, and common aspergillosis-causing pathogen in birds and mammals. Infection takes place following the aspiration of fungal spores, and is primarily a respiratory disease. *Aspergillus* infections are usually considered to be opportunist following other primary infections, immunosuppression or stressful environmental conditions. Small numbers of spores can usually be tolerated by the immune system, but large numbers can cause disease and death. At present, prevention is the only effective method of controlling aspergillosis in wild bird populations.

This project is concerned with studying the ecology of *A. fumigatus*, and identifying the most likely source/s of infection in hihi. Therefore, this project is directed towards identifying the most likely source/s of *A. fumigatus* rather than the most likely causes of aspergillosis in hihi. In doing so, the primary aim of this project is to investigate

whether previous hihi translocations from Little Barrier Island to young growth forests and forest edge habitats have been exposing birds to elevated levels of *A. fumigatus*, and therefore, whether *A. fumigatus* preventative management should be considered when planning future hihi translocations.

This project aimed to, A) determine whether habitat disturbance encourages the establishment of *A. fumigatus* in the environment B) measure and compare *A. fumigatus* densities from early growth regenerating forests (i.e., Mokoia and Tiritiri Matangi Islands), a pristine mature forest (i.e., Little Barrier Island), and two mainland forest locations (i.e., Mt Bruce Wildlife Centre, and the Massey University Campus) C) measure and compare *A. fumigatus* densities in forest edge habitats and inner forest locations. D) investigate whether hihi nest boxes on Mokoia Island and natural tree cavity-nests on Little Barrier Island are promoting the growth of *A. fumigatus* and, E) investigate various types of forest disturbance events that could account for the differences in *A. fumigatus* densities found between study sites.

Results from Chapter One describe a unique and previously unreported cicada disease caused by a *Conidiobolus* fungus on Mokoia Island. Results from Chapters Two and Three report elevated levels of *A. fumigatus* on Mokoia Island and at the Mt Bruce Wildlife Center. Low levels of *A. fumigatus* were recorded on Little Barrier Island, and moderate levels recorded for Tiritiri Matangi Island. Results indicate that forest disturbance promotes the abundance of *A. fumigatus* in the environment, and that forest edge habitats have significantly higher levels of *A. fumigatus* compared to inner forest locations. This suggests that forest disturbance alters natural disease dynamics, and increases bird`s exposure to opportunistic disease-causing agents such as *A. fumigatus*. These results, in part, illustrate the functional significance of old growth forests in keeping weedy pest species like *A. fumigatus* in check. Results from Chapter Four report that hihi are exposed to elevated levels of airborne *A. fumigatus* spores while in the nest box. Additionally, results indicate that hihi re-using old nest sites would further suffer increased exposure to *A. fumigatus* spores.

Because hihi are a vulnerable species, and seem to be particularly susceptible to aspergillosis, the conservation value of this work is high. This study was made possible by grants from the J.S.Watson Conservation Trust, Massey University Graduate Research Fund, and the World Wide Fund for Nature, and furthers our understanding of mortality factors affecting free-living birds, and provides new information on the ecology of this common wildlife disease. The broader implications of this work for managing wildlife, particularly birds in New Zealand forests are also explored. The relationship between clear-felling forest regrowth, and the incidence of aspergillosis may be the key to understanding the fate of bird populations re-introduced into forests, and determine the viability of "mainland islands".

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