THE ECOLOGY OF CHYTRIDIOMYCOSIS, AN EMERGING INFECTIOUS DISEASE OF AUSTRALIAN RAINFOREST FROGS

Thesis submitted by

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for the degree of Doctor of Philosophy
in Zoology and Tropical Ecology
within the School of Tropical Biology
James Cook University

DEDICATION

To my friend and coworker, Jesus.

"Let everything that has breath praise the LORD...."

--Psalm 150:6

STATEMENT OF ACCESS

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June 14, 2004

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ABSTRACT

In the wet tropics of Queensland, Australia eight species of stream dwelling frogs have experienced population declines, and individuals have been found with fungal infections of *Batrachochytrium dendrobatidis*, an emerging infectious disease of amphibians. I examined infection prevalence in stream frog assemblages and determined that amphibian chytrid infection is now endemic and persists in adults and tadpoles of declining and non-declining species at all eight streams surveyed. Infection prevalence varied among species, and between adult and tadpole life history stages, seasons, and elevations. Prevalences were higher during the dry season (May to September) and at high elevations (600-800 m). Tadpoles of *Litoria nannotis*, *L. rheocola*, and *Mixophyes shevilli* may be carrier hosts in this system; they have infection prevalences between 48 and 76%, and appear to be resistant to disease. Non-carrier hosts may include adults of all species and tadpoles of some species, with infection prevalence below 10%.

I found no relationships between infection prevalence and body condition, fluctuating asymmetry of hind limbs, population density, or the presence of metamorphosing tadpoles and juvenile frogs. I examined how environmental temperature and moisture regimes influenced the chytrid pathogen on frog hosts and in culture. Infected *Litoria chloris* juveniles survived at the lowest rates in constant mist and constant 20°C conditions, but frogs in constant dry or rain conditions survived longer. All frogs exposed to 37°C on days 12 and 13 after infection survived in good health for 9 mo after infection, and were found to be free of infection.

I modelled growth of chytrid populations using *in vitro* experiments to estimate the parameters zoospore production, zoospore survival rate, zoospore settlement rate, and time to sporulation of sporangia. The chytrid lifecycle may be faster at higher temperatures (23°C) than at lower temperatures (8°C), but relatively greater production of zoospores and better survival rates at lower temperatures may cause chytrid colonies to grow faster under cold conditions.

In addition to environmental effects, host immune function and behaviour may also alter host-pathogen dynamics. I found that leukocyte populations in juvenile *Litoria chloris* responded to infection but not to environmental conditions. Skin peptide immune

defences were more effective in common species (*Litoria lesueuri*, *Litoria genimaculata*, *Mixophyes shevilli*) and less effective in some endangered species (*Litoria rheocola*, *Nyctimystes dayi*). Skin peptide defences against the chytrid were also better in those species that showed greater survival when experimentally infected with *B. dendrobatidis*. Environmental conditions may also affect skin peptide immune response, with poorer responses under colder conditions.

The behaviour of captive *Litoria chloris* juveniles varied with thermal and hydric environments and time of day, but not infection status. *Litoria genimaculata* tadpole behaviour did vary with infection status; tadpoles exposed to chytrid sporangia showed a behavioural fever of 6.2 to 7.1°C. The conservation status of the rainforest stream frog species examined was correlated with their ranking on a disease risk assessment of behaviour; however, their current infection prevalence is not well correlated with disease risk. This agrees with epidemiological theory, which suggests that a disease involved in population declines should be present in both common and endangered species, but should have higher infection prevalence in species with stable populations. These stable species are also less at risk from chytridiomycosis based on behavioural and immunological assessments. The emergence of chytridiomycosis may occur when a particular host-pathogen interaction is achieved involving the complex arrangement of species assemblage structure and environmental conditions.

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My fascination with wildlife, and my conservation ethic, although now part of my nature, are due primarily to my Dad. My mom is also a source of love and encouragement to me. I think they would be proud of me no matter what career I chose.

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DECLARATION

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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June 14, 2004

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