Conservation Management of Two Threatened Frog Species in South-Eastern New South Wales, Australia

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Submitted in total fulfillment of the requirements of the degree Doctor of Philosophy at the University of Canberra

June 2007

Abstract

The decline and extinction of amphibian species over the past three decades is widely acknowledged as one of the greatest biodiversity crises of modern time. Providing convincing data to support hypotheses about these declines has proved difficult, which has greatly restricted the development and implementation of management actions that may prevent further amphibian declines and extinctions from occurring. In this thesis, I present research that was undertaken as part of the recovery programs for the southern corroboree frog (*Pseudophryne corroboree*), and the Booroolong frog (*Litoria booroolongensis*); two species that underwent very rapid declines in distribution and abundance during the 1980's. More specifically, I investigated potential causal factors in the declines of both species using experimental and correlative studies, and examined the mechanisms by which one threatening process (chytridiomycosis) may be causing continued decline and extinction in *P. corroboree*. I also examined the implications of population dynamics for monitoring *L. booroolongensis*, and suggest a possible monitoring strategy that may reliably facilitate the implementation of recovery objectives for this species. I also tested one possible reintroduction technique aimed at preventing the continued decline and extinction of *P. corroboree* populations.

In Chapters 2 and 3, I present the results from a series of experiments in artificial enclosures designed to examine whether the tadpoles of *L. booroolongensis* are susceptible to predation by co-occurring introduced predatory fish species; brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), European carp (*Cyprinus carpio*), redfin perch (*Perca fluviatilis*), and mosquito fish (*Gambusia holbrooki*). I demonstrated that the tadpoles of *L. booroolongensis*, and a closely related species *Litoria lesueuri*, were palatable to non-native trout species, but not to two native predatory fish species, *Gadopsis bispinosus* and *Galaxias olidus*. A pond breeding frog species included in this experiment, *Limnodynastes tasmaniensis*, was palatable to both the native and non-native fish species. In a separate experiment I also demonstrated that the tadpole of *L. booroolongensis* is palatable to the three other introduced fish species examined in this study; *C. carpio*, *P. fluviatilis*, and *G. holbrooki*. In three of the experiments, the provision of rock within enclosures as a potential refuge habitat did not afford protection to *L. booroolongensis* tadpoles from

predation by any of the five introduced fish species examined. While all the introduced fish species tested here did consume *L. booroolongensis* tadpoles, the results also suggested that chemical unpalatability might afford some level of protection against some of these fish species. Firstly, the addition of alternative prey items in one of the experiments reduced the proportion of tadpoles consumed, suggesting that *L. booroolongensis* may not be a preferred prey item. Secondly, the proportion of tadpoles consumed varied greatly among the different fish species examined, suggesting differing levels of palatability. Overall, this study supports previous research in suggesting that chemical unpalatability may be an important strategy for the tadpoles of riverine frog species in south-eastern Australia to avoid predation by native fish species, and that this strategy is less effective against introduced fish species. While *L. booroolongensis* currently persists in streams inhabited by a number of introduced fish species, this study supports the likelihood that these species are having a negative impact on populations of *L. booroolongensis* in the wild.

In Chapter 4, I present the results of a study aimed at examining potential monitoring techniques for *L. booroolongensis*. The results of a mark-recapture exercise demonstrated that *L. booroolongensis* may exhibit large fluctuations in abundance from one year to the next, and through a prospective power analysis approach, I demonstrated that it would be difficult to confidently identify population trends of interest using either indices or estimates of abundance for this species. An assessment of the capacity to identify the presence or absence of *L. booroolongensis* using night-time spotlight surveys demonstrated the high detectability of this species using this technique, at both the scale of 300-meter sections of stream and individual breeding areas (typically less than 10-meters of stream). This study suggests that the monitoring objectives of the *L. booroolongensis* recovery program would be most effectively achieved using presence/absence surveys at different scales.

In Chapter 5, I present the results of a field survey aimed at determining the current distribution and habitat requirements of *L. booroolongensis* in the South West Slopes region of New South Wales. Of the 163 sites I surveyed across 49 streams, I located *L. booroolongensis* along 77 of these sites from 27 streams. Based on population and habitat connectivity, this study identified 18 populations of *L. booroolongensis* that are likely to be operating as independent populations. Twelve of these populations are not represented in conservation reserves, but rather occur along streams that flow through the agricultural landscape. A broad scale habitat analysis identified a positive relationship between extent of rock structures along the stream and the occurrence of *L. booroolongensis*, and a negative relationship between the proportion of canopy cover and this species' occurrence. At the breeding habitat scale, this study identified a positive relationship between the presence of breeding males and; number of rock crevices in the aquatic environment, extent of emergent rocks, and proportion pool. This analysis also detected a negative relationship between occupancy and water depth. These results confirm previous work suggesting the importance of rocky stream habitats to the persistence of *L. booroolongensis*, but also suggest how disturbance processes, such as increasing sedimentation and weed invasion, may reduce the suitability of rocky structures as breeding sites.

In Chapter 6, I investigated current levels of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) infection in corroboree frog populations, and used retrospective screening of museum specimens to assess the possibility that this pathogen was implicated in the initial decline of the corroboree frogs. Using histology, I did not detect any *B. dendrobatidis* infections in corroboree frog populations prior to their decline, however using the same technique, moderate levels of infection were detected in post-decline populations of both species. Real-time PCR screening of skin swabs identified much higher overall infection rates in post-decline populations of *P. corroboree* (between 44% and 59%), while significantly lower rates of infection were observed in *P. pengilleyi* populations (14%). These results suggest that the initial and continued decline of the corroboree frogs may well be attributed to the emergence of *B. dendrobatidis* in populations of these species.

In Chapter 7, I investigated how *B. dendrobatidis* may be causing the continued decline of *P. corroboree* through the presence of an abundant reservoir host for this pathogen. I found that populations of adult *C. signifera* in sub-alpine bogs carry high *B. dendrobatidis* infection rates (86%), but appear unaffected by this infection. An experiment involving the release of *P. corroboree* tadpoles into 15 natural pools resulted in metamorphs from seven of these pools testing positive for *B. dendrobatidis*, with all these individuals dying soon after metamorphosis. These results support the possibility that *B. dendrobatidis* infection in *P. corroboree* populations is being facilitated by the presence of large numbers of infected *C. signifera* in the shared environment.

Chapter 8 presents the results of a population augmentation study for *P. corroboree.* I investigated the extent to which increasing recruitment to metamorphosis may result in population recovery in this species. This was undertaken by harvesting eggs from the field and rearing them through to mid stage tadpoles over the winter period prior to being released back to their natal ponds in spring. While I was able to increase recruitment to metamorphosis by an average of 20 percent, this did not result in a noticeable influence on the subsequent adult population size, as both manipulated and non-manipulated sites declined over the course of this study by an average of 80 percent. I observed a positive relationship between natural recruitment to a late tadpole stage and subsequent adult male population size, however there was considerable variation associated with this relationship. The relationship between recruitment and subsequent population size at the augmentation sites was consistent with the relationship observed at the non-manipulated sites. These results suggest that recruitment to metamorphosis may not be the most important life stage restricting the population recovery of *P. corroboree*, but that mortality during post-metamorphic stages may be more important in regulating current population size. Hence, further attempts to use captive rearing to increase *P. corroboree* populations in the wild should focus on the release of post-metamorphic frogs.

Overall, this thesis demonstrates the value of quantitative research to the implementation and progress of threatened species recovery programs. While this research will specifically contribute to the recovery programs for *L. booroolongensis* and *P. corroboree*, it more broadly contributes to the understanding and capacity to respond to the concerning levels of amphibian extinctions currently occurring throughout the world.

Acknowledgements

The research undertaken in this thesis was made possible through the provision of funding from the following organisations; Australian Research Council, NSW Department of Environment and Climate Change, University of Canberra, Co-operative Research Centre for Freshwater Ecology, NSW Fisheries, Murray Catchment Management Authority and Amphibian Research Center. I am indebted to staff in the NSW National Parks and Wildlife Service offices in Tumut and Khancoban for their efforts in assisting many aspects of this work. Chapters 6, 7 and 8 are the result of continued support and guidance by the Corroboree Frog Recovery Team.

I am very thankful to all those who provided me with field assistance and company throughout this research; Sean Doody, Michelle Walter, Rod Pietsch, Mike Smith, Lachlan Farrington, Alex Knight, Alex Quin, David Bourne, Martha Reese, Dieuwer Reynders, Russel Traher, David Judge, Rajani Rhy, Colin De Pagder, Craig Smith, Jessica Rossell, Michael McFadden, Yoko Shimizu, Ty Mathews and Jamie Molloy. Claire Steel is owed particular thanks for undertaking much of the husbandry for Chapter 7. I am particularly thankful to Mike Smith and Michael Scroggie for their assistance with the statistical analyses in Chapters 2 and 5. Jason Baldwin and Tony Day (NSW Fisheries) provided considerable assistance in many aspects of this project. I also thank Bob Faragher and Roy Witstanly (NSW Fisheries) for capturing the fish used in Chapter 3, and also Brian Free and the Tumut Acclimatisation Society for the use of their shed. Rick Speare and Diana Mendez undertook the histology and screening of specimens in Chapter 6, and provided much advice and comment on this chapter. I am particularly appreciative to all the property owners and managers I visited during the surveys in Chapter 5, who allowed me access through their land, and shared their wealth of knowledge about the streams in the South West Slopes region. Kylie Durrant and Cherie White provided much local knowledge and advice that greatly facilitated the surveys undertaken in Chapter 5. I also thank the following for fruitful advice and discussions at various stages through my thesis; Tony Tucker, Murray Evans, Sean Doody, Arthur Georges, Graeme Gillespie, Nick Clemann and Glen Johnson.

I am especially thankful to the following people for their contributions to this thesis and my capacity to undertake it. Firstly, I probably wouldn't have embarked on this project if it wasn't for the encouragement of Scott Keogh and Paul Doughty – unfortunately Plan A didn't quite work out. My supervisor Will Osborne provided constant support and advice during all phases/directions of my PhD work, and was particularly helpful during the final write-up. Michael Smith has been an invaluable source of support, advice and amusement during this thesis. I am particularly indebted to Mike Saxon and Rod Pietsch for their support as colleagues and supervisors during this research – they have definatley inspired me to keep pursuing a career in this field. I am greatly indebted to Gerry Marantelli for his innumerable contributions to this thesis and his tireless efforts in our broader endeavors - I hope one day we celebrate success! My family (Mum, Dad, Jonathan, Meggsie, Allie, Steven and Dorrie) provided much valuable support during periods when I was away from home.

The second half of my PhD journey has been a relatively painless exercise thanks to the love and fulfillment in my life from Dieuwer, Ollie and Manu. In addition to the direct support and sacrifices they made for my research, they importantly gave me the capacity to put this thesis into perspective.

Table of Contents

List of Tables

List of Figures