

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**The triumphs, challenges and failures of young
North Island brown kiwi (*Apteryx mantelli*): a study of
behaviour, growth, dispersal and mortality**



**A thesis in partial fulfilment of the requirements for the degree of
Master of Science in Zoology
at Massey University, Palmerston North, New Zealand**

Alexandra Louise Wilson

2013

Abstract

North Island brown kiwi (NIBK, *Apteryx mantelli*), an endemic New Zealand species, are estimated to have declined by 90% from pre-human colonisation numbers. Currently, at least 60% of mortality is attributed to introduced mammalian predators, namely stoats (*Mustela erminea*) preying on chicks. Therefore, conservation effort focuses on predator trapping/killing, and hatching and rearing NIBK chicks in captivity and releasing them back into the wild. These efforts are resulting in increased recruitment of chicks into populations. However, little is known about the biology and behaviour of NIBK chicks in the wild and how this may affect management of these populations. Consequently, the aim of this study was to examine the ecology of young wild NIBK in a natural high density population with reduced predator diversity on Ponui Island. More specifically, the goal was to determine their growth rates, behaviour around the natal nest, dispersal and mortality, and how these factors may be influenced by environmental variables. During the 2010 - 2011 and 2011 - 2012 breeding seasons 29 young NIBK were observed from hatching until mortality or the end of 2012. Remote video cameras were set up outside nests to record behaviour. Juveniles were located daily as often as possible and location, habitat type, roost type and visibility were recorded. Growth measurements of weight, bill and tarsus lengths were taken monthly in the first season and weekly in the second. Invertebrate abundance and availability were also measured using pitfall traps and soil penetrability. Lastly, young NIBK found dead were preserved in formalin and sent for autopsy to accurately determine the cause of death.

NIBK on Ponui Island were found to grow slower $K_g = 0.0052$ than a NIBK population measured previously at Lake Waikaremoana ($K_g = 0.006$) and 296 other bird species measured to date using the Gompertz growth curve. Females grew faster than males for the first 90 days after hatching. Sample size was too small to do further comparisons after this age. The rate of growth for body mass increased with age whereas the rate of growth for bill length and tarsus length decreased with increasing age, until at least 90 days of age. On a monthly scale, with increasing temperature food abundance significantly increased and soil penetrability declined; on a weekly scale temperature significantly affected growth rates with NIBK growing fastest between 19 - 22°C. I hypothesised that this was because with

increasing temperature, food abundance increased, until a point where the soil became too hard for NIBK to probe for food resulting in the optimum growth rate between 19 - 22°C.

In 161 nights of nest observation I observed seven interactions between a chick and the adults at the nest. These observations are interesting because NIBK were not previously known to interact with their young outside the nest. The behaviours are ambiguous and therefore I was unable to be sure of the context. Juveniles changed roost location most days and the movements between roost sites of individuals were highly variable. Daily dispersal distance was significantly affected by temperature and season, juveniles moved further in the warmer seasons and there was a positive relationship between dispersal distance and temperatures.

Lastly, the mortality rate of NIBK in this population was high at 87.5% with most young NIBK dying from natural causes such as starvation and disease before 90 days of age. Cat predation was found to be higher at 30% relative to mainland populations where cat predation contributes to 5 - 9% of mortalities.

This study highlights that population density, temperature, food availability and causes of mortality other than predation are important factors to consider when researching, conserving and translocating NIBK.

Acknowledgments

I could never possibly thank everyone enough for their contributions and help with this thesis; big or small, I will be forever grateful.

Thank you to my amazing supervisors Isabel Castro and Sarah Jamieson. I have enjoyed my time so much with you. You are both incredibly encouraging, insightful and went above and beyond what could ever be expected as supervisors; from the late night phone calls, days in the bush, good times and bad, many revisions and edits, you put up with it all and we are still great friends at the end.

To the Chamberlin Family, never have I met a nicer group of people. To Dave and Ros, Peter and Pat, I have loved being part of your family and being involved with life on the farm. Thank you for letting us work with your kiwi, play on your farm, putting up with endless requests, knowing about everything, and always having something exciting going on. Thanks to the girls, Louise, Megan and Michelle for just being awesome. I could not think of a place more special to spend so much of my time.

I could not have done all the work I did without my volunteers, putting in so much work and effort – you were absolutely amazing and in turn I learnt so much from you. Thank you to Katy Gibb and Catherine Jardine for all your initial inspiring ideas, keeping me sane in the bush at night (occasionally), helping me get lost and entertained 24/7. To Allyson Larned, Amanda Pavese and Laura Bramley and also Rose Swift and Steph Walden, you guys are amazing individuals, I had so much fun, you worked so incredibly hard and I will forever be in your debt. You also bumped America up on my to-do list! Thanks Lizzy Perrett and Dean Jakings, I had a lot of fun with you in the bush, I think you both knew a lot more than me and I'm very glad you liked it so much here and decided to come back! Thanks Lizzy for reading some very long revisions. You guys will always have a place in my heart, and a couch to sleep on when you come back to New Zealand.

Thanks to Tom and Jamie, you guys were awesomely entertaining, kept me on my toes, and trusted my direction an awful lot in the bush – on second thoughts maybe not so wise. Good luck to those that are starting out on Ponui: Alex, Natasha and Tom, enjoy your time, make the most of every opportunity and I know you will all do amazingly in your studies.

Thank you Charlie for understanding my craziness, putting up with a long distance relationship and for understanding my running away to the island a few weeks of every month for the past few years. I couldn't have done any of this without your support and love. Love you always.

Thanks to all my friends that have put up with my running away, missing occasions, quick random catch ups, and for always being there when I come back. Specifically to Tess who always knows when a coffee or chocolate is necessary and to Mish who amazingly read a number of my first 'terrible' efforts at this thesis and helped me through.

To everyone else at Massey who helped me in some way shape or form, thank you, your help was greatly appreciated. Thank you to Sharon who was always around to help with anything, Clel who fixed many a broken TR4, Paul who supplied endless numbers of hard-drives and other gear and Ellen who helped out with a number of autopsies. A large thank you to Maurice Alley who carried out numerous autopsies, without which we could not have provided such in-depth information about the mortality of chicks in this population. Thank you to Lee Shapiro, who started the work and ideas surrounding the behaviour of chicks and thank you for the use of your data. Lastly, thank you to those that provided photographs in this thesis.

My family has always supported anything I've wanted to do, likewise with this thesis they helped me so much through the good and the stressful times. Dad reading everything I wrote, and Mum and Bec ready with a hug and some goodies to get me through. I'm so glad I got to share this world and the kiwi with you. Thank you Mum, Dad and Becs so much for your support and help.

This project was funded with the help of the following scholarships: Massey University Institute of Agriculture and Environment Summer Scholarship, the Julie Alley Bursary, the Graduate Women's Manawatu Postgraduate Scholarship; and funds from an anonymous individual and the San Diego Zoological Society to my supervisors. I would have been very hard pressed to do any of this research without it and for that I am eternally grateful.

For Gotham, Charlie, Babe and Becca

Contents

Abstract	iii
Acknowledgments	v
List of Tables	x
Appendix	xi
Chapter 1: Literature Review and Introduction	2
General Biology and Ecology of Kiwi	2
<i>Conservation</i>	3
Growth	5
<i>Environmental factors that affect growth rates</i>	7
<i>Additional factors that influence Growth</i>	9
<i>NIBK Growth</i>	10
Behaviour and learning of young animals	12
<i>Parental Care</i>	12
<i>NIBK Parental care</i>	14
Natal and Juvenile dispersal	16
<i>NIBK Dispersal and Habitat selectivity</i>	18
Mortality	23
<i>Yolk sac</i>	24
<i>Environmental factors</i>	25
<i>Mortality in NIBK</i>	26
Aims, Contribution and Study Site	28
<i>Purpose of this study</i>	28
<i>Aims</i>	28
<i>Importance of Thesis</i>	28
<i>History of NIBK at the Study site</i>	29
<i>Study site and subjects</i>	30
<i>Permits and Animal Ethics:</i>	32
Chapter 2: Factors influencing growth rates of an extreme precocial species: North Island brown kiwi	34
Introduction	34
Methods	37
<i>Monitoring</i>	37
<i>Seasonal measures</i>	37
<i>Statistical analysis</i>	40
Results	42

<i>Growth in relation to sex</i>	45
<i>Growth between seasons</i>	46
<i>Weather and Resources</i>	46
<i>Effect of weather and resources on weight gain</i>	48
Discussion	50
<i>Growth rate</i>	50
<i>Growth Rate Trends</i>	55
<i>The influence of climate on growth rates</i>	56
<i>The influence of life history on growth rates</i>	57
Appendix 2.1	60
Chapter 3: Behaviour of North Island brown kiwi chicks at the nest	68
Introduction	68
Methods	70
<i>Monitoring</i>	70
<i>Behavioural data</i>	71
<i>Statistical Analyses</i>	71
Results	72
<i>Social Interactions</i>	76
<i>Adult interactions</i>	78
Discussion	79
Chapter 4: Understanding movements of young North Island brown kiwi	84
Introduction	84
Methods	87
Results	91
Discussion	94
Chapter 5: Mortality of juvenile North Island brown kiwi in a population with low predator diversity	100
Introduction	100
Methods	102
Results	104
Discussion	107
Chapter 6: Main discussion	112
References	118

List of Figures

Figure 1.1. a) Aerial photograph of New Zealand, Ponui Island, b) Aerial photo graph of Ponui Island, c) Study site with three main gullies demarcated in white.....	31
Figure 2.1. Map of the study site, the three catchments on Ponui Island, New Zealand. Plotted are the locations of pitfall traps.....	39
Figure 2.2. Growth rates of North Island brown kiwi on Ponui Island a) Body mass, b) Bill length, c) Tarsus length.....	44
Figure 2.3. Growth rates of four North Island brown kiwi during three breeding seasons on Ponui Island that survived to the end of from hatching until March 2012.....	45
Figure 2.4. Growth rates of 29 North Island brown kiwi during the three breeding seasons on Ponui Island.....	46
Figure 2.5. Environmental variables, food abundance and availability on Ponui Island, New Zealand from the 2010 and 2011 seasons. a) Invertebrate abundance, b) Mean monthly temperature, c) Mean soil penetrability, d) Monthly rainfall.....	47
Figure 2.6. Effects of environmental variables on mass growth rate (RGR) in young North Island brown kiwi using path analysis.....	49
Figure 2.7. Hypothesis of North Island brown kiwi growth rates in different situations.....	53
Figure 3.1. North Island brown kiwi chick behaviour at the nest on Ponui Island, New Zealand from 2010 - 2012. The number of times chicks were seen in the nest entrance each night at different ages.....	73
Figure 3.2. North Island brown kiwi chick behaviour at the nest on Ponui Island, New Zealand from 2010 - 2012. The number of times chicks of different ages were seen leaving the nest each night.....	73
Figure 3.3. North Island brown kiwi chick behaviour at the nest on Ponui Island, 2010 - 2012. a) Average time spent in the vicinity of the nest, b) Index of probing behaviour while in the	

vicinity of the nest, c) Mean number of tumbles each chick did at different ages, d) ‘Sniffing’ behaviour of chicks when close to natal nest.....74

Figure 3.4. The order of nightly departure from the nest, of chicks and incubating male North Island brown kiwi on Ponui Island, 2010 - 2012.....76

Figure 4.1. Estimate of the distance young North Island brown kiwi need to move from their natal nest to disperse outside their parent’s home range.....89

Figure 4.2. Distance from the nest that 17 juvenile North Island brown kiwi were found roosting during the day at different ages on Ponui Island, New Zealand in the 2010 and 2011 seasons.....92

Figure 4.3. Habitat type young North Island brown kiwi were located in from 1 - 14 weeks of age on Ponui Island, New Zealand in the 2010 and 2011 seasons.....93

Figure 4.4. Roost types that 17 juvenile North Island brown kiwi were found hiding in or around on Ponui Island, New Zealand in the 2010 and 2011 seasons.....94

Figure 5.1. Average age at death for each of the primary causes of young North Island brown kiwi mortality on Ponui Island, 2010 -2012.....107

List of Tables

Table 1.1. Dispersal distances of North Island brown kiwi from other studies and locations20

Table 2.1. General trend of life history traits in precocial species and North Island brown kiwi.....51

Table 2.2. Growth rates for first 100 days after hatching of young North Island brown kiwi from captive and wild populations.....54

Table 5.1. Mortality statistics for 21 young North Island brown kiwi on Ponui Island during 2010 - 2012.....104

Appendix

Table 2.3. Measurements of 29 North Island brown kiwi that hatched on Ponui Island in the 2004, 2010 and 2011 seasons.....	60
Table 2.4. Invertebrate abundance in grams of dry mass weight from pitfall traps on Ponui Island, New Zealand from November 2010 – March 2012.....	64
Table 2.5. Invertebrate abundance in numbers of individual invertebrates from pitfall traps on Ponui Island, New Zealand from November 2010 – March 2012.....	65
Table 2.6. Adapted from Starck and Ricklefs (1998a) showing species whose growth rates constants (K) are <0.05.....	65