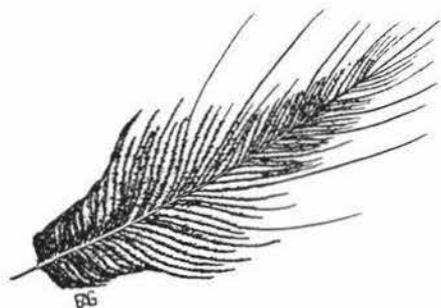


Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

115
6139

Comparative ecology of Northern brown
kiwi (*Apteryx australis mantelli*) in
Tongariro National Park and Tongariro
Forest Park, central North Island.

Jonathan Roger Graham Miles
February 1995



A thesis presented in partial fulfilment of the requirements for the degree of Master of Science at Massey University, Palmerston North.



Frontispiece: Author holding "Tahi" (M.51) a Northern Brown kiwi male, Tongariro Forest Park, April 1994.

To my family and friends

'Like winds and sunsets,
wild things were taken for granted
until progress began to do away with them.
Now we face the question,
whether a still higher 'standard of living'
is worth its cost in things
natural, wild and free.'

- Aldo Leopold.

Acknowledgements

This study would have been impossible if not for the support and encouragement from the following people. Murray Potter, for having faith in me and my abilities, for willingly sharing his wealth of experience of kiwi with me, for guidance through, and constructive criticism of this thesis, and especially for introducing me to this extraordinary bird. Cam Speedy for his support in the field, this provided me peace of mind for when I was in the back and beyond, and for his dedication towards everything "natural, wild and free." Harry Keys for his guidance and support, in particular his searching and intuitive questions regarding the study. Graeme Calder for field assistance, without it much of the information would not have been gathered, and for his patience with me, and his ability to see a job through until the end. Robin Fordham for valuable discussions on aspects of the study and mainly for constructively criticising drafts of the thesis. John McLennan for his advice, and willingness to share and discuss information. Alastair Robertson for his statistical patience. Kathryn Whaley for support, and thoughtfulness, and keeping things together, and up and running at home when I was away.

I also depended so much upon the generosity and support of so many other people that any attempt to properly acknowledge their help is bound to be inadequate. It is anything but a polite phrase to say that without their assistance, this study and thesis would not have been possible. In no particular order, I wish to thank: Rob McCallum, Hugh Robinson, Jan Clayton-Green, Martin Clapham, Greg Meikle, Paul Green, Paul Dale, Cathy Jones, Barbara Just, Liz Grant, Clare Veltman, Ed Minot, Ian Stringer, Kim King, Phil Battley, Jill Rapson, Isabel Castro, Dale Towers, Andrea Booth, Gary Bramley, Jackie Townsend, Vanessa Munro, Edwin Smith, David Fountain, Al Rowland, Ian Henderson, Jens Jorgensen, Ian Townsend, Stephanie Prince, Greg Carlyon, Dave Lumley, Iain Maxwell, Sid Puia, Neil Small, Peter Mark, Barbara Curtis, Paul Barrett, Steve Pilkington, Vaughan Keesing, Tracey Bourner, the Whaley family, Linda Glover, Erica Reid, Petra van Kan, Peter van Essen, Brian Springett, Alison Franklin, Glennis Wallbutton, Tim Mitchell, John Allen, Mike Brown, Sue Brown, Don Bogie, Dave Rothschild, Alison Rothschild, Maureen Smith, Phil Smith, Catherine Foster, David Hodgson, Ian Millner, Prue Grant, Bill Rollerson, Paul Edhouse,

Rosemary Miller, Warren Furner, Ian Goodison, George Taituma.

This thesis will no sooner go to the binders than I will probably remember several other people who made important contributions. I apologise for any such omissions. Also, I must point out that despite the length of the list of those who assisted my efforts, I managed to make whatever mistakes all on my own.

This study was funded by Department of Conservation research contract 1489, Tongariro/Taupo Conservancy, Massey University, and my parents.

Abstract

Biological aspects of calling, range size, roost choice, feeding ecology, and potential threats faced by Northern brown kiwi (*Apteryx australis mantelli*) are described for a 14 month study in two conservation areas in central North Island, Tongariro National Park and Tongariro Forest Park.

In Tongariro Forest Park 73% of calls were made by males. The 3:1 ratio of male:female calls changed seasonally, with the proportion of female calls increasing over winter and spring. Total call rates also increased during these seasons. Between nights call rates varied irrespective of season. Temperature and rain accounted for 44% of this variation. During the night, calling behaviour was bimodal, with the majority of calls occurring in the first and last three hours of darkness. In winter and spring males called, on average, 20 minutes later than in summer and autumn. Thirty times more calls hour⁻¹ were heard in Tongariro Forest Park than in Tongariro National Park. Density of kiwi was estimated to be 1 bird/km² in Tongariro National Park, and 4 birds/km² in Tongariro Forest Park. This suggests that call rates are not linearly related to the number of kiwi present in an area. Practical implications of this for the interpretation of kiwi call surveys are discussed.

Home ranges of kiwi varied from 30.8 to 91.8 ha. Range size of paired females tended to be larger than those of paired males. The range of an unpaired male was significantly larger than those of the paired males and paired females. Female home ranges overlapped more than male home ranges.

Kiwi varied considerably in their choice roost. Roost type was dependent on habitat type. Roosts associated with fallen trees and surface roots were the most frequently used type. Kiwi infrequently used one roost site more than once, those roosts that were reused were large burrows of unknown size. Male kiwi used surface vegetation more often than females, while the females favoured roosts associated with hollow logs, and/or roots. Territory size may be a consequence of habitat.

During 14 months of sampling, higher numbers and greater taxonomic diversity of invertebrates was found in Tongariro Forest Park than in Tongariro National Park with 55% of taxa common to both areas. Seasonal changes in the taxa found in faeces reflected seasonal changes in apparent invertebrate abundance. Kiwi also appeared to

focus on a particular taxon, suggesting that they are selectively opportunistic feeders.

Mammalian predators pose a major threat to the long-term survival of kiwi in the central North Island. Predator surveys indicated possums, cats, dogs, and stoats were present in Tongariro Forest Park and Tongariro National Park. A ferret was caught in Tongariro National Park, and pigs were observed only in Tongariro Forest Park, but probably ferrets and pigs are present in both sites. No significant difference was found between the numbers of stoats trapped in the two study areas. Local morphometric variation appeared to occur, with adult male stoats collected in Tongariro National Park being larger, on average, than their counterparts collected in Tongariro Forest Park. There were differences between areas in the average size of prey items with the average size of prey being larger in Tongariro Forest Park than in Tongariro National Park.

Future conservation and management issues for Northern brown kiwi are discussed.

Contents	Page
Acknowledgements	iv
Abstract	vi
List of figures	xii
List of tables	xiv
Chapter 1 Introduction	
1.1 Introduction	1
1.2 Aim of the study and thesis plan	2
Chapter 2 Biological aspects of calling and the practical implications, in a population of Northern brown kiwi (<i>Apteryx australis mantelli</i>).	
2.1 Introduction	5
2.2 Study area	6
2.3 Methods	9
2.3.1 Statistical analysis	9
2.4 Results	10
2.4.1 Origin of calls	10
2.4.2 Intra-pair calling	11
2.4.3 First call after sunset	11
2.4.4 Changes in call rates	15
2.4.5 Variation within nights	19
2.4.6 Relationship between call rates and density in Tongariro	19
2.5 Practical implications	24
2.5.1 Analysis of the first calling peak	24
2.5.2 Broadcasting calls in areas with different kiwi densities	24
2.5.3 Which calls elicit the greatest response	27
2.5.4 Length of sampling needed	27
2.5.5 Territory mapping	27
2.6 Discussion	29
2.6.1 Function of calls	29
2.6.2 Factors affecting calling	30
2.6.3 Density, call rates, and mapping	32
2.7 Practical implications	33

Contents	Page
2.7.1 Deriving an accurate estimate or index	33
2.7.2 Territory mapping	34
Chapter 3 Range size and roost choice of Northern brown kiwi (<i>Apteryx australis mantelli</i>) in the central North Island.	
3.1 Introduction	35
3.2 Methods	36
3.2.1 Capture of kiwi	36
3.2.2 Telemetry	36
3.2.3 Birds captured and tracking period	37
3.2.4 Frequency of tracking and handling	37
3.2.5 Estimation of range size	38
3.2.6 Daytime roost and habitat description	39
3.2.7 Amount of available habitat	39
3.2.8 Habitat analysis	40
3.2.9 Statistical analysis	41
3.3 Results	41
3.3.1 Home range estimation	41
3.3.2 Preference	44
3.4 Discussion	49
Chapter 4 Food availability and diet of Northern brown kiwi (<i>Apteryx australis mantelli</i>) in two adjoining conservation areas in the central North Island.	
4.1 Introduction	53
4.2 Study areas	53
4.2.1 Tongariro National Park	53
4.2.2 Tongariro Forest Park	54
4.2.3 Invertebrate survey sites	54
4.3 Methods	56
4.3.1 Statistical analysis	57
4.4 Results	58
4.4.1 Food distribution	58

Contents	Page
4.4.2 Differences in numbers of invertebrates and taxonomic diversity between areas	58
4.4.3 Differences in invertebrate abundance and taxonomic diversity within areas	58
4.4.4 Faecal analysis	61
4.4.5 Availability of taxa and their occurrence in kiwi diet	64
4.4.6 Preference or "avoidance" of taxa	65
4.4.8 Biomass contribution	65
4.5 Discussion	72
4.5.1 Seasonal availability of invertebrates	72
4.5.2 Occurrence of taxa in kiwi diet	73
4.5.3 Habitat diversity, invertebrate abundance and taxonomic diversity	74
4.5.4 Relative importance of taxa to diet in terms of biomass and availability	75
4.5.5 Vegetative component of diet	77
4.5.6 Food as a limiting resource	77

Chapter 5 Index of predators: potential threats to the survival of Northern brown kiwi (*Apteryx australis mantelli*) in the central North Island.

5.1 Introduction	78
5.2 Methods	79
5.2.1 Study sites	79
5.2.2 Indexing mammalian predators	79
5.2.3 Trap layout	79
5.2.4 Trapping tunnels	79
5.2.5 Biological preparation of specimens	80
5.2.6 Morphological measures	80
5.2.7 Age determination	80
5.2.8 Diet analysis	81
5.2.9 Data analysis	82
5.3 Results	83
5.3.1 Mammalian predators identified in each site	83
5.3.2 Central North Island stoats	84

Contents	Page
5.3.3 Geographic variation in size with change in habitat type	84
5.3.4 Sexual dimorphism	85
5.3.5 Diet	88
5.4 Discussion	90
5.4.1 Predator assemblages	90
5.4.2 Predator density	91
5.4.3 Morphometric variation	91
5.4.4 Influence of predator assemblages and density on kiwi in central North Island	93
 Chapter 6 General summary and recommendations for future conservation and management of Northern brown kiwi (<i>Apteryx australis mantelli</i>).	
6.1 Introduction	94
6.2 General summary	94
6.2.1 Study sites and general methodology	94
6.2.2 Biological aspects of calling and the practical implications	95
6.2.3 Range size and roost choice	97
6.2.4 Feeding ecology	97
6.2.5 Potential threats: predator indexing	99
6.3 Management recommendations	100
 References	 101
 Appendices	
Appendix 1 The influence of environmental variables on calling activity.	109
Appendix 2 Kiwi Call Scheme card.	110
Appendix 3 Maximum R-square Improvement.	112
Appendix 4 Calls heard in the interval between broadcasting calls.	117
Appendix 5 Response interval of mate after one of the pair called.	118
Appendix 6 Measurements of Tongariro kiwi.	119
Appendix 7 Range size estimation, and 50% core areas.	121
Appendix 8 Seasonality of taxonomic groups found in faeces.	123
Appendix 9 Availability and utilisation of taxonomic groups.	126
Appendix 10 Average taxonomic diversity and total numbers of invertebrates.	127
Appendix 11 Exotic mammal accounts.	128
Appendix 12 Measurement of Tongariro stoats.	131

List of figures

Figure	Page
Frontispiece: Author holding "Tahi" (M.51) a Northern brown male, Tongariro Forest Park, April 1994.	ii
1.1 Location of Tongariro National Park and Tongariro Forest Park.	4
2.1 Location of listening stations in Tongariro Forest Park and Tongariro National Park used between December 1992 to December 1993.	8
2.2 Average number of duets heard for every 24 hours of listening each month, November 1992 to December 1993, in Tongariro Forest Park.	12
2.3 Time after sunset the first kiwi call was heard during different months and night length in Tongariro Forest Park, December 1992 to December 1993.	13
2.4 Mean time elapsed (minutes) between sunset and first male call.	14
2.5a Seasonal variation in the calling rates in Tongariro Forest Park, December 1992 to January 1994.	17
2.5b Calling rates of kiwi in Tongariro Forest Park with intra-pair calling (duets) removed.	17
2.6 Average calling rates of kiwi in Tongariro Forest Park in relation to weather.	18
2.7 Average calling rates per season of kiwi in Tongariro Forest Park in relation to the percentage of the night which had elapsed when the calls were heard.	21
2.8a Average calling rates of kiwi in Tongariro National Park and Tongariro Forest Park.	22
2.8b Call rate versus kiwi density.	23
2.9 Total number of calls heard in the first four hours of darkness, and percentage probability of no calls occurring in that particular hour.	26
2.10 Effects of increasing sample size on estimates of average calling rate.	26
3.1 Spacial distribution of kiwi in Tongariro Forest Park.	43
3.2 Proportion of roost types found in the four main habitat types.	48

Figure	Page
4.1 Availability of annelids in Tongariro Forest Park and Tongariro National Park.	62
4.2 Utilisation of annelids reflected by average number of chaetae per faecal pellet	62
4.3a Availability and utilisation by kiwi of surface, litter, and soil dwelling invertebrates in Tongariro Forest Park.	69
4.3b Availability and utilisation by kiwi of surface, litter, and soil dwelling invertebrates in Tongariro National Park.	70
5.1 Tail lengths of adult male stoats in Tongariro Forest Park and Tongariro National Park.	86
5.2 Condylbasal lengths of adult male stoats in Tongariro Forest Park and Tongariro National Park.	86
5.3 Body weights of adult male stoats in Tongariro Forest Park and Tongariro National Park.	87
5.4 Hind foot lengths of adult male stoats in Tongariro Forest Park and Tongariro National Park.	87

List of tables

Table	Page
2.1 Average call rates hr^{-1} in Tongariro Forest Park during fine nights and nights with rain.	16
2.2 Average call rates hr^{-1} in Tongariro Forest Park in relation to weather changes.	16
2.3 Average call rates hr^{-1} in Tongariro Forest Park in relation to the presence or absence of moonlight.	16
2.4 Seasonal ratio of male : female calls heard in the first and second halves of the night in Tongariro Forest Park.	19
2.5 Change in average call rate hr^{-1} in response to broadcast calls.	25
2.6 Change in average call rate hr^{-1} in response to broadcast calls in the first hour of darkness.	25
2.7 Change in average call rate hr^{-1} in response to broadcast calls in the second hour of darkness.	25
2.8 Change in average call rate hr^{-1} of female kiwi in response to a taped male or taped female call.	28
2.9 Change in average call rate hr^{-1} of male kiwi in response to a taped male or taped female call.	28
2.10 Average call rate hr^{-1} of male and female kiwi in response to taped calls.	28
3.1 Range size of kiwi in Tongariro Forest Park and Tongariro National Park.	42
3.2 Habitat area and proportion of the total range (availability), for each of six habitat types.	45
3.3 Numbers and percentages of radio-tracking locations in each habitat type (utilisation) for kiwi within their home range.	45
3.4 Calculation of the Chi-square statistic (test of preference) for all kiwi.	46
3.5 Confidence intervals for the proportion of time each kiwi spent in each habitat type.	46
3.6 Conclusions on preference and/or avoidance by the four kiwi towards the six habitat types.	47

Table	Page
4.1 Analysis of variance table for total number of individual invertebrates caught in Tongariro Forest Park and Tongariro National Park.	69
4.2 Analysis of variance table comparing taxonomic diversity of invertebrate taxa caught in Tongariro Forest Park and Tongariro National Park.	60
4.3 Zonal differences in invertebrate numbers.	60
4.4 Zonal differences in taxonomic diversity.	61
4.5 Average weights of taxa, their zone of capture, and their weight contribution in proportion to availability and utilisation.	63
4.6 Availability of the three feeding zones in terms of taxa.	66
4.7 Utilisation of the three feeding zones by kiwi.	66
4.8 Calculation of the Chi-square statistic (test of preference) for feeding zones.	67
4.9 Confidence intervals for the proportion spent feeding in each feeding zone by kiwi.	67
4.10 Conclusions on preference or under-utilisation of feeding zones by kiwi.	68
4.11 Preference of particular taxa by kiwi in Tongariro Forest Park and Tongariro National Park.	71
5.1 Mammalian predators present in Tongariro National Park and Tongariro Forest Park.	83
5.2 Details of the age ratios of the total stoat sample by month.	84
5.3 Comparison between morphometric measures of adult male and female stoats collected in both Tongariro National Park and Tongariro Forest Park.	85
5.4 Prey identified in stoat stomachs.	88
5.5 Number and percent frequency of occurrence of prey in stoat stomachs.	89
5.6 Contribution of identified prey items to the diet of stoats collected in both areas.	90