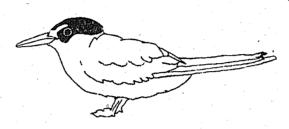
Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

OGS 10
MASSEY UNIVERSITY APPLICATION FOR APPROVAL OF REQUEST TO EMBARGO A THESIS (Pursuant to AC 98/168 (Revised 2), Approved by Academic Board 16.02.99)
Name of Candidate: <u>Sara Treadqold</u> ID Number: <u>97215340</u>
Name of Candidate: <u>Sara Treadqold</u> ID Number: <u>97215340</u> Degree: <u>M5c</u> Dept/Institute/School: <u>Ecology</u> <u>INR</u>
Thesis Title: Behavioural ecology of the endangered New Zealand Faining Tern (Tara iti) Sterna nereis davisae implications for management
Tern (Tara iti) Sterna nereis davisae implications for management
Name of Chief Supervisor: A/P Rabin Fordham Telephone Extn: 2605
As author of the above named thesis, I request that my thesis be embargoed from public access
until (date) <u>September 2001</u> for the following reasons:
Thesis contains commercially sensitive information.
Thesis contains information which is personal or private and/or which was given on the basis that it not be disclosed.
Immediate disclosure of thesis contents would not allow the author a reasonable opportunity to publish all or part of the thesis.
Other (specify):
Discourse in the second state is the second state of the second st
Please explain here why you think this request is justified:
aunder to sour long more field work and
Meas nome no publish rey results
Signed (Candidate): Java Treadgold Date: 25/8/2000
Endorsed (Chief Supervisor): RA Jordham Date: 24 Aug 2000
Approved/Not Approved (Representative of VC):
Note: Copies of this form, once approved by the representative of the Vice-Chancellor, must be bound into every copy of the thesis.

1

Behavioural ecology of the endangered New Zealand Fairy Tern (Tara-iti) *Sterna nereis davisae*: implications for management



A thesis presented in partial fulfillment of the requirements for a degree of Masters of Science in Ecology

at

Massey University, Palmerston North New Zealand

Sara Jane Treadgold

2000

To Jarn whose friendship I will always treasure

Acknowledgements

Although I endeavoured to keep a list of those that helped me, there may be people that slipped through the gaps in my mind. For this I do humbly apologise and hope that they know that I do appreciate their help.

To my supervisors Robin, Ed and Dave for their continuous encouragement, great advice, and Robin for the odd sweet or two to keep those waning sugar levels up to keep me going through it all. ⁽ⁱⁱ⁾ A big thank you my friend Gwenda Pulham for her encouragement, support and friendship and being the inspiration behind my taking this project on. ⁽ⁱⁱⁱ⁾

Thanks to Rae and Gavin McGregor for being such a positive and generous couple. I humbly thank them both for an amazing time and for their support, particularly helping with those harrowing measurements (Louise too for this one). ^(C) Also thanks to Sybil Canning for letting me stay and putting up with me coming and going at all hours. Thanks to Pepe (for such kindness, for all those beautiful flounder, and the loan of Gerty), Alex and Christine (for letting me and others stay at your house), and Betty and Stan for making me feel so welcome on the Kaipara. Also thanks to Margaret and Richard for the accommodation even though I never seemed to be there. ^(C)

Thanks to John Dowding for endeavouring and succeeding to catch these little birds for me and his wife Elaine for keeping the two of us in touch. To Bill Walsh and Philip Wright, Jed Gibson, Jean-Anne, Margaret, Clare Exley, Tony Moore, Gavin Grant, Michael Taylor, Gordon Gorbe, Simon Chamberlain, Tony Harbaken, Adrian Reigan, and Barabara and Malcolm Wallar for all the help in the field. ⁽²⁾ Thanks to the Auckland Ornithological Society for letting me use some of the archival photographs and Tony Crocker for publishing my article. Thanks also to Boyd Goodwin for his dedication at Papakanui and braving winds and sand in the eyes to watch the birds for me.

Thanks to Ray Pierce, Graeme Taylor, Shaarina Taylor, and Richard Parrish and the wardens Katrina, Leigh, David, Jennie, Doug, Sarah and Lester from the Department of Conservation; to Martin, Kelly and Brian from Auckland Zoo, and Brian Gill for their help and friendship.

For help with the blood sampling and analysis, thanks to Bert Westera, Paul Barret, Isabel Castro, Craig Miller and Richard Jacob-Hoff, Danielle, Nicci, Richelle, Hillary, Pete, and a BIG thank you to Leon. Thanks very much to Jodi, Erica, Barbara, Hamish and Hayden for all the 'behind the scenes' help which kept things from coming to a grinding halt. Also thanks to Cathy for getting up at all hours to help out with field work and giving me a rest from it all for a while. ^(C) Thanks to Duncan Hedderley for statistics help with some curly data. Ian Henderson for his gracious help with ordinations and the maps. Liz Grant for the many hours of tinkering to make my maps. Also to Jim Reside and Clint Shipner for suppling me with some badly needed Australian literature. Thanks to Ray for keeping my car going, and Helen and Moria for getting me through some hard times.

A special thanks to Dorothy and Maurice Alley for believing in me. I am sure that Julie would have approved and I am honoured to have had help to do this project in her memory. Thank you for your friendship and very generous nature.

To my friends Halema, Grant, Rob, Mike, Elissa, Wayne, Vivian, Reece, Dave, Carlos, Ash, Wendy, Mike van, John, Alyn, Tas (for those designer chapter covers too ⁽²⁾), Kylie Kat, Angela, Nathan and Windy for their help, support, endless cups of coffee, card nights, and the great fun that I had in your company. ⁽²⁾ To Woody, thanks particularly for braving the weather in doing those labourous measures and rescuing my photos from under the deck. ⁽²⁾ To my family: Cliff, Ellen, and Marjorie thank you for your friendship, loving support and laughs throughout. ⁽²⁾ Particular thanks goes to my brother Michael for your friendship, always being there for me and for keeping me afloat. Oh and HE HE, I finished first Bud, ⁽²⁾ not that it was a competition, really. ⁽²⁾

Lastly thanks to Jarn, for you're every kindness, your friendship and your caring soul. For all your support and love, making me laugh, and reminding me not to shout at the universe. ⁽²⁾ Also for all those late night sessions of Babylon 5, bringing my insanity into a world of unreality for a few hours a night. ⁽²⁾ My universe is such a better place with you there. ⁽²⁾

"Home is not a place, it's wherever your passion takes you" Capt. John Sheriden (Babylon 5)

Table of Contents

P	a	g	e
_		0	-

Abstract	• • • • • • • • • • • • • • • • • • •	• • • • • • • • • • • • • • • • • • • •	i
Acknowledgements	-		
Table of Contents	• • • • • • • • • • • • • • • • • • • •		iv
List of Figures		· · · · · · · · · · · · · · · · · · ·	viii
List of Tables	14		
List of Appendices	••••••		xi

Cha	apter 1. General Introduction	. 1
1.1	Introduction	1
1.2	Description	6
1.3	Study Sites	8
	1.3.1 Mangawhai	9
	1.3.2 Waipu	.13
	1.3.3 Papakanui	. 14
1.4	Past and Present distribution	
1.5	Behavioural Ecology	
	1.5.1 Reproduction	.19
*	1.5.2 Longevity	21
	1.5.3 Nutrition	21
1.6	Thesis Objectives	
1.7	Thesis Organisation	.22
	References	

v

Chapter 2. Breeding ecology of the New Zealand Fairy Tern: the role of the	e sexes
during reproduction and how the environment can alter behaviour	30
	•
2.1 Introduction	30
2.2 Methods	34
2.2.1 Collection of data	34
2.2.2 Statistical analysis	
2.3 Results	
2.3.1 Incubation	
2.3.2 Parental care of the young	43
2.3.3 Feeding of the young	
2.4 Discussion	
2.5 References	
	·····

 Chapter 3. The response of New Zealand Fairy Terns to interactions with other birds

 and people: implications for management ______________________________64

3.1	Introduction	••••	•••••		• • • • • • • • • • •	•••••	64
3.2	Methods			••••	• • • • • • • • • •		
	3.2.1 Collection of data.			••••••	•	·	67
	3.2.2 Statistical analysis	• • • • • • • • • • • • • • • • • • • •		•••••	• • • • • • • • • •		67 [.]
3.3	Results	••••			•••••	• • • • • • • • • •	68
3.4	Discussion						
3.5	References		•••••	•••••			

Chapter 4. Nest-site selection in the New Zealand Fairy Tern: a comparison of environmental characteristics of nest sites and the surrounding available habitat

4.1	Introduction		82
4.2	Methods	{	86
	4.2.2 Statistical analysis		ə1
4.3			
4.4	Discussion		99
4.5			06

Cha	apter 5. Determining the sex of New Zealand Fairy Terns: implications for	. 7
beh	navioural ecology and management	118
		•
5.1	Introduction	118
5.2	Methods	120
	5.2.1 Tissue collection	120
	5.2.2 DNA extraction, precipitation and PCR techniques	121
	Whole blood	121
	Feathers	122
5.3	Results	124
5.4	Discussion	126
5.5	References	. 130

vi

82

Cha	apter 6. Thesis synthesis and Recor	nmendati	ons	-			135
			~ 8				* *
6.1	Thesis Synthesis	•••••					135
6.2	Recommendations	• • • • • • • • • • • • • •	-			• • • • • • • • • • •	137
6.3	Future work and directions	••••	•••••			••••••	139
6.4	Conclusions			•••••			140
6.5	References	•••••	,	•	••••		141

List of Figures

Figure 1.1. The post-breeding plumage of the New Zealand Fairy Tern
Figure 1.2. The eclipse stage of the New Zealand Fairy Tern between its breeding and
non-breeding plumage
Figure 1.3. Map of the present breeding sites of the New Zealand Fairy Tern of
Mangawhai, Waipu, and Papakanui, Northland, North Island, New Zealand 10
Figure 1.4.1. Overlooking Mangawhai Spit from the Mangawhai Heads 12
Figure 1.4.2. Waipu Spit from the south end of the spit12
Figure 1.4.3. Papakanui Spit south-west from South Head, Kaipara Harbour 13
Figure 1.5. Map of the past distribution of the New Zealand Fairy Tern
Figure 1.6. A New Zealand Fairy Tern egg compared with a size-six chicken egg 20
Figure 2.1.1. (a) The individual differences in the incubation stints at Mangawhai with
time of day in the pairs in the 1998/1999 season including the manipulation. (b)
excluding the data collected after the manipulation
Figure 2.1.2. (c) The individual differences in the incubation stints at Mangawhai with
time of day in the pairs in the 1998/1999 season with the data collected after the
manipulation only. (d) The incubation behaviour of the Waipu pair in the 1998/1999
season
Figure 2.2.1. Changes in parental activities over week for each pair at (a) Mangawhai
and (b) Waipu in the 1997/1998 season
Figure 2.2.2. Changes in parental activities over week for each pair at (c) Mangawhai
and (d) Waipu in the 1998/1999 season
Figure 2.3.1. Changes in parental activities over time the day for the Mangawhai pair in
(a) the 1997/1998 season and (b) the 1998/1999 seasons
Figure 2.3.2. Changes in parental activities over the time of day for the Waipu pair in
the 1998/1999 season
Figure 3.1.1. Passive and active responses of Fairy Terns to other bird species and
people during the incubation period (a) Mangawhai pair (b) Waipu pair 69
Figure 3.1.2. Passive and active responses of Fairy Terns to other bird species and
people during the care of the young (a) Mangawhai pair (b) Waipu pair 70

Figure 4.1.1. Map of Mangawhai Spit with general features and location of the
nests
Figure 4.1.2. Map of Waipu Spit with general features and location of the nests 88
Figure 4.1.3. Map of Papakanui Spit with the general features and location of the
nests
Figure 4.2.1. A scatter plot of the chosen nests and the available habitat with vectors of
the environmental characteristics showing how they are correlated
Figure 4.2.2. A scatter plot illustrating the PCA ordination of the east coast nest sites as
compared to those on the west coast
Figure 4.2.3. A scatter plot illustrating each nest and its associated available
habitat
Figure 4.2.4. A scatter plot showing the strong influence which elevation had on the
ordination to split the two coasts on axis one
Figure 4.2.5. A scatter plot showing the influence that distance to nearest vegetation
had on the ordination to split the two coasts on axis one
Figure 4.2.6. A scatter plot showing the influence that vegetation height had on the
ordination to split the two coasts on axis one
Figure 5.1. An example of profiles resulting from PCR amplification of genomic DNA
from 3 female and 3 male Fairy Terns 124
Figure 5.2. Comparison of the morphological measurements of male and female New
Zealand Fairy Terns

х

List of Tables

Table 2.1. The breeding success of pairs observed in the study
Table 2.2. The mean and standard errors of the complete incubation stints of the male
and female in the 1997/1998 and 1998/1999 seasons 39
Table 2.3. The results from the Lifereg procedure performed on the incubation stints of
the pairs observed in the 1998/1999 season 40
Table 2.4. Mean and standard errors of time (minutes) spent guarding, brooding and
absent from young over the 1997/1998 and 1998/1999 seasons
Table 2.5. The significant interactions of the main effects in relation to the three
activities (brooding, guarding of an adult and absence from the young) performed by the
parents over the 1997/1998 and 1998/1999 seasons 44
Table 2.6. Summary of the role of the sexes in terns during incubation and care of the
young
Table 3.1. Active responses of the Mangawhai Fairy Terns and their significance
level with respect to different factors
Table 3.2. Active responses of the Waipu Fairy Terns and their significance level with
respect to different factors
Table 4.1. Environmental variables and a summary of the sampling methods used to
analyse the nesting habitat of New Zealand Fairy Terns
Table 4.2. Shows each breeding site, nest code, the female and male of the pair
associated with each nest, nest attempt and the outcome of each nest measured 93
Table 4.3. The results from the logistic regression model showing which environmental
characteristics were important in the choice of nest sites by the New Zealand
Fairy Tern 99
Table 5.1. Assignment of sex in the Fairy Tern in the 1997/1998 and 1998/1999
breeding seasons based on the occurrence of high molecular fragments and on
behavioural data 125

List of Appendices

Appendix 1.1. The scientific names of bird species mentioned in the text using only the
common names
Appendix 4.1. The scatter plots showing how the environmental characteristics
influenced the split of the west and east coast in the ordination
Appendix 4.2. Standardised nest values, and the means, minimum and maximum value
for the surroundings available habitat of the environmental characteristics to establish
nest-selection selection in the New Zealand Fairy Tern 11: