THE LITTLE SHEARWATER IN THE 1994 BREEDING SEASON ON LADY ALICE ISLAND: BREEDING SUCCESS, AND TIMING AND CAUSES OF BREEDING FAILURE.

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13 March 1995

ISSN 1171-9834

Reference to material in this report should be cited thus:

Booth, A.M., 1995.
The Little Shearwater in the 1994 breeding season on Lady Alice Island breeding success, and timing and causes of breeding failure.
Conservation Advisory Science Notes No. 115, Department of Conservation, Wellington. 10p.

Commissioned by: Northland Conservancy
Location: NZMS

1. INTRODUCTION

Data for this report were collected during a 1994 study of the breeding biology and ecology of the Little Shearwater (*Puffinus assimilis haurakiensis*) on Lady Alice Island, in the Hen and Chickens Group. Kiore (*Rattus exulans*) were present on Lady Alice Island during most of the study, but were eradicated in November 1994 following a Department of Conservation poisoning campaign. Tuatara (*Sphenodon punctatus*) are also present on Lady Alice Island. This report discusses the breeding success of the Little Shearwater on Lady Alice Island during the 1994 breeding season, the timing of breeding failure, and the possible causes of breeding failure.

2. METHODS

2.1 Breeding Success, Timing of Nesting Failure, and Causes of Nesting Failure

Six trips of between eight days and three weeks duration were made to Lady Alice Island during the 1994 Little Shearwater breeding season. Little Shearwater burrows at four different sites on the island (Fig 1) were monitored. The canopy and sub-canopy vegetation at each of the four sites was recorded (Appendix 1). Burrows occupied by breeding pairs were marked and numbered with tree tape. Egg laying dates were recorded or estimated for each breeding pair, and birds were banded, and sexed by cloacal examination where possible. Adult attendance at the nest site during incubation was determined by setting up a 'fence' of twigs over the burrow entrance, or by looking through an observation hole dug above the nesting chamber before breeding commenced. When pairs failed at the incubation stage, eggshell remains were collected and photographed, and nesting material was sorted for signs of failure.
Chick hatching dates were recorded, and chicks weighed daily until they fledged. Little Shearwater breeding success at each site was determined.

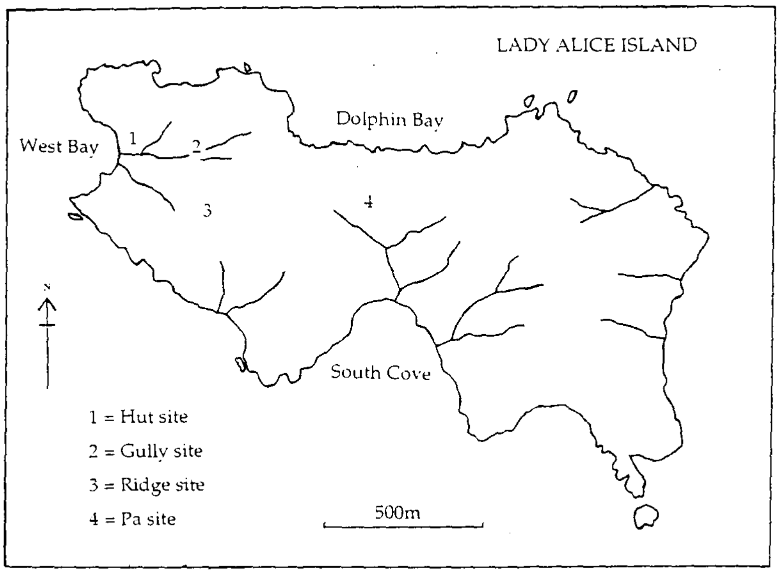

Fig. 1: Position of study sites on Lady Alice Island.

2.2 Use of Video Gear to Film Predation Events

A timelapse video recorder was used at two nesting chambers. In both cases it was run on 18 hour timelapse. At the first burrow (Hut #4), which had an unattended egg, the camera was run for a total of 64.5 hours over 5 nights. At the second burrow (Ridge #164), which initially had an incubating Little Shearwater present, the camera was run for a total of 157 hours over 11 nights. After one predation event was filmed at Burrow 164, a depression was made in the nest material so that an egg could not be rolled out of the nesting chamber, and the Little Shearwater egg was replaced by a punctured hen's egg.

2.3 Use of Caged Kiore

A hen's egg with a small hole made in it was placed in a cage with three kiore and left for several hours. The egg was removed from the cage after it had been broken open by the kiore. This provided eggshell remains known to have been preyed on by kiore, for comparison with eggshell remains found in the study burrows.

3. RESULTS

3.1 Breeding Success

A total of 29 nests containing adult Little Shearwaters incubating eggs were found at the start of the breeding season. Of these nests 16 (55%) failed during the incubation stage. A total of 13 eggs hatched, and of these 2 chicks (15%) did not survive to fledge. The overall breeding success of Little Shearwaters in the study burrows was 38%.

3.2 Timing of Failure

The mean incubation period of the Little Shearwater was 57±1.1 days (n=4). The date at which incubation failed was recorded for nine nests, and ranged from 25 to 59 days after laying (mean = 42± 11.4 days). Seven nests failed while I was absent from the island, and in these nests failure may have occurred between 2 and 69 days after laying.

The mean failure date after laying for nests in which predation by kiore was suspected, and for which the actual failure date was known, was 43 ±9.2 days

One chick disappeared from it's nest chamber at one day old. In another burrow a second chick disappeared at between 11 and 39 days old.

3.3 Suspected Causes of Failure

Eleven (68.8%) of the 16 nests which failed during incubation contained eggshell remains with signs of damage typical of rat predation (J. Innes. *pers. comm*.). Damage to the eggshells included large holes in either end or along one side of the egg, and toothmarks and signs of gnawing around the holes. More droppings were also found in several burrows which contained broken eggs. Two (12.5%) of the nests may have failed because Little Shearwater adults broke the eggs. Three (18.8%) of the nests showed no indication of the

cause of failure during the incubation stage. For both of the nests which failed at the chick stage, no sign of the cause of disappearance was found.
Details of the timing and cause of failure for each unsuccessful burrow are given in Table 1.

Table 1: Timing and suspected cause of failure of Little Shearwater breeding pairs on Lady ALice Island, 1994.
laying date estimated

Burrow number	Site	Stage at which failure occurred	Days after laying/hatching	Suspected cause of failure
2	Hut	egg	37-54	kiore
3	Hut	egg	28-47#	?
4	Hut	egg	29	kiore
177	Hut	chick	11-39	chick disappeared
110	Gully	egg (infertile?)	59	Little Shearwater adult
176	Gully	egg (infertile)	47-69#	kiore
25	Ridge	egg	34	kiore
26	Ridge	egg	2-17	kiore
28	Ridge	egg	8-22#	?
46	Ridge	egg	24-42#	kiore
53	Ridge	chick	1	chick disappeared overnight
62	Ridge	egg	46#	kiore
65	Ridge	egg	25	Little Shearwater adult
81	Ridge	egg?	56# egg pipping	kiore
85	Ridge	egg	45#	kiore
164	Ridge	egg	52	kiore - on video
170	Ridge	egg	36	kiore
179	Ridge	egg	23-41#	?

3.4 Failure of nests in relation to the length of time eggs were left unattended by parents.

The percentage of days that eggs were left unattended by parents at each site when I was present on Lady Alice Island are shown in Table 2. There was no significant difference in the length of time eggs were left unattended at each site (ANOVA $F[3,19] = 0.36$, $p=0.779$).

Table 2: Percentage of days eggs were left unattended at each study site on Lady Alice Island, 1994.

Site	Eggs laid	%
1 - Hut	8	21
2 - Gully	6	12
3 - Ridge	12	12
4 - Pa	3	28

3.5 Failure of nests in relation to nesting habitat

The timing of failure rate and overall breeding success at each study site is shown in Table 3. The Pa site had the highest overall breeding success rate (100%), while the Ridge site had the lowest (0%). The Hut and Gully sites had the same egg hatching rate (67%), though fledging success was slightly higher at the Gully site. There was a significant difference in the rate of breeding success between sites ($X^2=14.816$, df=3, $0.005<P<0.001$).

Table 3: Overall breeding success of Little Shearwaters at each study site on Lady Alice Island, 1994.

Site	Eggs laid	Eggs hatched	Chicks fledged	Overall breeding success
1 - Hut	8	5 (63%)	4 (80%)	50%
2 - Gully	6	4 (67%)	4 (100%)	67%
3 - Ridge	12	1 (8%)	0 (0%)	0%
4 - Pa	3	3 (100%)	3 (100%)	100%

3.6 Filmed Predation Events

Video filming of Burrow 4 (Hut site) on 21 September 1994 produced evidence of a kiore visiting the nesting chamber one night before the egg in that burrow was preyed on. The camera was moved to another burrow the next day, so that predation event was not filmed.

In Burrow 164 (Ridge site) at 0250hrs on 14 October 1994, a kiore was filmed rolling an uncracked Little Shearwater egg out of the nesting chamber. The egg was removed from the chamber in nine seconds. This egg was recovered the next morning in the burrow leading to the nesting chamber, and photographed (Fig. 2). The egg showed signs of damage that are typical of rat predation (J. Innes, *pers. comm*.), such as a large hole broken out of the narrow end of the egg, and toothmarks around the hole.

A kiore was filmed preying on the punctured hen's egg in Burrow 164 at 2035hrs on 14 October 1994. The hen's egg was broken open by the kiore and eaten in full view of the camera. A kiore returned to the nesting chamber four times during the same night in visits that lasted between seven seconds and about five minutes.

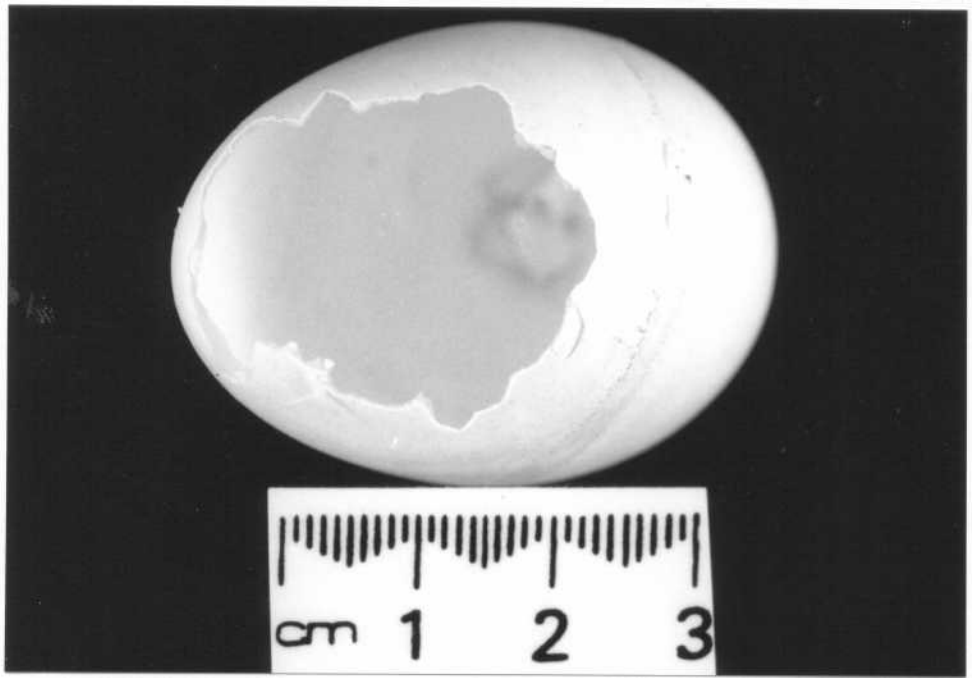

Fig. 2: Remains of the Little Shearwater egg rolled out of Burrow 164 by a kiore.

3.7 Predation of Hen's Egg by Caged Kiore

The hen's egg which was placed in a cage with kiore sustained damage similar to that seen in Little Shearwater eggs thought to have been preyed on by kiore (J. Innes, *pers. comm.*)

DISCUSSION

Predation by kiore of eggs, chicks, or adults has already been documented for several seabird species (Kepler 1967; Thoresen 1967; Bell in Merton 1970; Fleet 1972; Imber 1978). This is the first study to report kiore predation of Little Shearwater eggs. Predation of eggs by kiore was the probable cause of failure for 68.8% (11) of the Little Shearwater nests which were unsuccessful during the incubation period. Kiore were the only rats present on Lady Alice Island at the time of the study, so no other rat species could have been responsible for the failed Little Shearwater nests.

All of the Little Shearwater eggs thought to have been preyed on by kiore carried signs of damage similar to that found on the hen's egg that was put in a cage with kiore. The only other potential predators of seabird eggs on Lady Alice Island are tuatara. Walls (1978) reported that tuatara ingest whole Fairy Prion eggs and leave very little eggshell remains, so it seems highly unlikely that tuatara caused the damage found on these eggs.

The video footage obtained during this study of a kiore rolling a Little Shearwater egg from a nesting chamber provides evidence that kiore interfere with the eggs of the Little Shearwater. This film, in conjunction with the recovered eggshell which carried signs of damage typical of rat predation, leaves little room for doubt that kiore are capable of breaking open undamaged Little Shearwater eggs. The video footage showing a kiore breaking open a punctured hen's egg provides evidence that kiore are capable of opening an egg once it is cracked. Little Shear water eggs may become cracked up to 8 days before hatching when the chick starts pipping (*pers. obs.*). Adults often leave eggs unattended for 1 night at this stage (*pers. obs.*), presumably to feed before the chick hatches. Therefore, Little Shearwater eggs are very vulnerable to kiore predation during the period of chick pipping and hatching.

The mean failure date of eggs probably preyed on by kiore was at around 6 weeks old. Grant *et al* (1981) suggested that the Black rat *R. rattus* learned to prey on petrel eggs as the breeding season progressed. If kiore are also able to learn how to exploit a potential prey item in this way, the risk of Little Shearwater eggs being preyed on would increase towards the end of the incubation period.

Predation of seabird eggs by kiore can be influenced by the rate at which eggs are left unattended by the adults (Imber 1984). As there was no significant difference between sites in the number of days that eggs were left unattended, this explanation cannot account for the large variation in hatching success between sites.

Little Shearwater breeding success was lowest at the Ridge site (0%), which was dominated by kanuka. Eight (72.7%) of the 11 nests which failed during the incubation stage at this site appeared to have been preyed on by kiore. The rate of predation at the Ridge site was much higher than at any of the other 3 sites. It would be very difficult to suggest that vegetation influenced the rate of kiore predation without measuring kiore densities and food availability at each of the 4 sites. These measures were not made. Woodward (*In* Grant et al. 1981) suggested that a group of kiore learned to attack nesting albatrosses on Kure Atoll. The high concentration at one site of eggs thought to have been preyed on by kiore may have been due to a group of kiore learning to exploit this food supply.

The possibility that the eggs were scavenged cannot be discounted. However, for this to happen, eggs would first have to be damaged by a Little Shearwater adult or a tuatara. But the rate of egg hatching success varied greatly between sites (Table 3), and it seems highly unlikely that Little Shearwater adults or tuatara would have damaged eggs at a much higher rate at the Ridge site than at the other 3 sites.

The effects of kiore on Little Shearwater chicks are uncertain. Little shearwater chicks are often left unattended within a day or two of hatching (*pers. obs*.). Seabird chicks are vulnerable to predation by rats at this stage, because they sleep a lot and cannot defend themselves very well (Imber 1978). The fact that two of the chicks in study burrows disappeared without trace suggests they were preyed on by kiore. However, kiore scavenging of dead chicks, or tuatara predation of chicks as has been recorded with Fairy Prions (Walls 1978), cannot be ruled out.

CONCLUSION

The Little Shearwater population on Lady Alice Island had a low breeding success rate (38%) in the 1994 breeding season. Predation by kiore was thought to be the cause of failure for 68.8% of the nests which failed during the incubation stage. The breeding success of the Little Shearwater population on Lady Alice Island was monitored in 1993 (R.J. Pierce unpublished data), so there are now records of Little Shearwater breeding success in the presence of kiore for two successive years. More were eradicated from Lady Alice Island in November 1994. Continued monitoring of the Little Shearwater population on Lady Alice Island would provide valuable data for comparing breeding success of a small seabird species before and after kiore have been eradicated from an offshore island.

ACKNOWLEDGEMENTS

Keith Hawkins, Ray Pierce, Ed Minot, Mike Imber and numerous volunteers assisted throughout the study. Paul Jensen loaned the video monitoring equipment, and John Innes commented on the recovered eggshell remains. Robin Fordham, Murray Potter, Isabel Castro and Johnathon Miles all commented on earlier drafts of the manuscript.

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APPENDIX 1: Canopy and sub-canopy plant species at each site.

Site 1- Hut

<u>Canopy</u>

Carmichaelia aligera	North Island broom
Coprosma spp.	
Cordyline australis	cabbage tree
Dysoxylum spectabile	kohekohe
Geniostoma rupestre	hangehange
Leptospermum ericoides	kanuka
Melicytus ramiflorus	whiteywood
Metrosideros excelsa	pohutukawa
Pseudopanax arboreus	five-finger
P. lessonii	houpara
Cyathea spp.	ponga

<u>Sub-canopy</u>

Brachyglottis repanda	rangiora
Clematis spp.	clematis
Coprosma spp.	-
Dysoxylum spectabile	kohekohe
Geniostoma rupestre	hangehange
Hebe spp.	-
Macropiper excelsum	kawakawa
Myrsine australis	mapou
Olearia furfuracea	akepiro
Phormium tenax	flax
Sophora microphylla	kowhai

Site 2 - Gully

<u>Canopy</u>

Corynocarpus laevigatus	karaka
Dysoxylum spectabile	kohekohe
Leptospermum ericoides	kanuka
Melicytus ramiflorus	whiteywood
Metrosideros excelsa	pohutukawa
Nestegis apetala	coastal maire
Sophora microphylla	kowhai
Vitex lucens	puriri

<u>Sub-canopy</u>

Brachyglottis repanda	rangiora
Hoheria populnea	lacebark
Macropiper excelsum	kawakawa
Myrsine australis	mapou
Pisonia brunoniana	parapara
Pseudopanax arboreus	five-finger
Rhabdothamnus solandri	waiuatua

Site 3 - Ridge

Canopy

Carmichaelia aligera	North Island broom
Dysoxylum spectabile	kohekohe
Leptospermum ericoides	kanuka
Melicytus ramiflorus	whiteywood,
Pittosporum umbellatum	haekaro
Pseudopanax arboreus	five-finger
Sophora microphylla	kowhai

Sub-canopy

Brachyglottis repanda	rangiora
Coprosma spp.	
Geniostoma rupestre	hangehange
Hebe spp.	
Hoheria populnea	lacebark
Macropiper excelsum	kawakawa
Myrsine australis	mapou
Olearia spp.	
Phormium tenax	flax
Pseudopanax arboreus	five-finger

Site 4 - Pa

Canopy

Beilschmiedia tarairi	taraire
Dysoxylum spectabile	kohekohe
Knightia excelsa	rewarewa
Leptospermum ericoides	kanuka
Metrosideros excelsa	pohutukawa
Nestegis apetala	coastal maire
Vitex lucens	puriri

Sub-canopy

Brachyglottis repanda	rangiora
Carmichaelia aligera	North Island broom
Coprosma spp.	
Geniostoma rupestre	hangehange
Hedycarya arborea	pigeonwood
Hoheria populnea	lacebark
Macropiper excelsum	kawakawa
Melicytus ramiflorus	mahoe
Myrsine australis	mapou
Olearia spp.	
Pittosporum umbellatum	haekaro
Pseudopanax arboreus	five-finger