SCIENCE AND RESEARCH INTERNAL REPORT N0.83

KAKAPO BREEDING ACTIVITY ON LITTLE BARRIER ISLAND 21 NOVEMBER 1989 – 10 APRIL 1990

by

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October 1990

ISSN 0114-2798

ISBN 0-478-01216-0

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ABSTRACT

Breeding activity by kakapo on Little Barrier Island was monitored throughout the period November 1989 to April 1990. The season was the most intense and extended booming season since kakapo were transferred to the island in 1982. The first two kakapo nests recorded on the island were found, but both nests failed.

1. INTRODUCTION

Thirteen male and nine female kakapo were transferred to Little Barrier Island between May and August 1982. One male was found dead in 1983.

Male courtship displays, called booming, have occurred on Little Barrier Island during five of the seven summers since the transfers. It has been assumed that nesting has not occurred on the island as there has been no evidence of copulation at the males' display sites (booming sites or track and bowls), and systematic surveys during the winters of 1986 and 1989 using bait lines, cage traps and trained dogs, failed to identify recruitment to the original translocated population (Veitch 1986 and Hodsell 1989).

This report describes the results of a programme to monitor male courtship behaviour on Barrier Island during the period December 1989 to April 1990 and provides an account of the first two kakapo nests recorded on Little Barrier Island.

2. METHODS

2.1 Male breeding activity

The methods used to monitor male kakapo courtship behaviour at booming sites on Little Barrier Island have been established by Moorhouse 1986, 1987, Dowding 1988 & Greene 1989. During this study these established methods were used with some modifications.

2.1.1 Monitoring of disturbance at booming sites

All known booming sites were inspected repeatedly throughout the period 21 November 1989 to 10 April 1990. The regularity of inspection varied from daily, for conveniently located active sites, to monthly, for remote and inactive sites. Any kakapo sign seen at, or near, booming sites was noted, e.g. grubbing, trimming of vegetation, feeding sign, droppings or feathers. Four short (5-10 cm) upright sticks and two crossed

sticks were placed in each bowl at a booming site, and subsequent disturbance to them was recorded as evidence of courtship behaviour.

As part of a concurrent supplementary feeding programme (Powlesland and Lloyd 1990), feeding stations were placed within 50 m of three active booming sites. Evidence of overnight feeding by kakapo at these feeding stations was recorded daily.

2.1.2 Monitoring booming

In contrast to other years there were no night vigils to listen for booming. Instead, small activated tape recorders were left at booming sites to record overnight activity. Olympus Pearlcorder tape recorders (models L200 and S930) were used with C60 tapes. A tape recorder was wrapped in two plastic lunch bags, switched onto voice activated mode and placed in a small hole (usually dug in a peat bank) within 200 mm of a bowl. Recordings were carried out at a tape speed of 1.2 cm/sec in order to extend the tape duration. The tapes were played back at 2.4 cm/sec both to speed up the playback process and to make booming audible on the tape recorder's small loudspeakers. Any sounds which could be attributed to kakapo were noted.

2.1.3 Identifying males at booming sites

Trained dogs were used to track kakapo from their booming sites to daytime roosts. Individual kakapo were then identified either from the colour combination on painted dual-colour bands or, after being recaptured by hand, by reading the numbered stainless steel leg bands which all transferred kakapo were fitted with before release on Little Barrier Island.

2.1.4 Feathers

The daily schedule of supplementary feeding and booming site inspection provided a method to monitor seasonal changes in feather loss. All kakapo feathers in the course of our work were collected and recorded.

2.2 Female breeding activity

2.2.1 Evidence of copulation

According to Powlesland (1989) large numbers of kakapo feathers at a booming site may be interpreted as indicating that copulation has occurred. The area around each booming site was therefore carefully examined for feathers during each inspection.

Clusters of feathers considered to be the result of copulation attempts were those in which feathers were restricted to a small area (<1 m^2) close to an active bowl (<3 m^2); the feathers were ground into the substrate and were primarily down feathers. In contrast, clusters of feathers considered to be the result of agonistic interactions were more widespread, extending over several metres; they were not ground into the substrate and a greater proportion of the feathers were contour feathers.

2.2.2 Locating and monitoring nests

Nesting activity was monitored by locating females during the probable nest period using trained dogs. Females for whom no nest was discovered were captured by hand and examined for the presence of a brood patch. In order to avoid human induced nest failure, nests were not monitored after their initial discovery.

2.3 Rat index trapping

Changes in the abundance of rats were assessed by using a rat index line which was run for three consecutive nights at two-month intervals. Ezeset rat traps baited with cheese were used. Two traps were placed at each site. Aluminium covers were placed trap to reduce the incidence of non-target kills. The traps were placed at 45 sites at 50 m intervals on Track 20 from approximately 150 m a.s.l. to 650 m a.s.l. Index traps were not placed within 50 m of the two kakapo feeding stations on Track 20.

3. RESULTS

3.1 Male breeding activity

3.1.1 Monitoring disturbance at booming sites

There are now 49 known booming sites on Little Barrier Island, including four new sites where activity was recorded this year but not in previous years. Disturbance associated with kakapo was detected at 26 of the 49 known sites during the period 21 November to 10 April 1990. The results of monitoring disturbance at these 26 active booming sites during this period are provided in the Appendix. In the appendix active sites are arranged geographically and grouped into 17 clusters or systems, each system comprising either one site or a number of adjacent sites probably used exclusively by a single male on any one night.

Figure 1 is a graph of the numbers of systems used by kakapo each night during the study period. The upper boundary to the grey area is the minimum numbers of systems used each night. These numbers comprise results only from those systems inspected on consecutive days. The upper boundary to the black area is the best estimates of the numbers of systems used each night. These estimates were obtained by interpolating between inspections for those systems not inspected on consecutive days.

On most nights between 30 December and 10 February kakapo activity was recorded at 9 systems. From 10 to 28 February the number of active systems increased to between 11 and 13. There was a rapid decline in the number of active systems at the beginning of March, possibly in response to a period of cold wet weather. Activity resumed at many systems midway through March and persisted until the end of the investigation on 10 April.

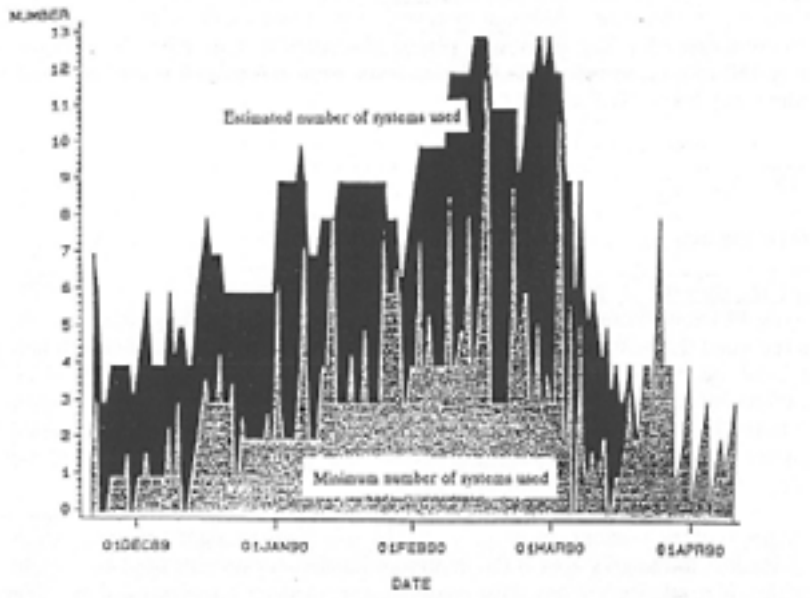
The patterns of disturbance observed at booming sites differed seasonally.

Early season (early November to late December):
: Bowls were excavated, and there was grubbing and trimming of vegetation in the area around booming sites.

Mid season (late December to mid-March):
: Disturbance was generally restricted to the main bowl, or bowls, which become quite deep.

Late season (mid-March to mid-April):
: There was extensive clipping of vegetation around booming sites; new bowls were formed and existing bowls left undisturbed; numerous droppings and feathers were found on the tracks within 100 m of the booming sites.

Figure 1. The number of booming systems used each night on Little Barrier Island during the period 21 Nov - 10 Apr 1990.



Evidence of kakapo feeding on the leaf bases of mountain neinei (*Dracophyllum pyramidale*) was common throughout the booimg season along the high-altitude ridges where booming sites occur.

3.1.2 Monitoring booming using tape recorders

Tape recorders were put out regularly during the periods 19 December to 16 February and 8 to 27 March, most commonly at booming sites 7, 8 and 9. (See Appendix 1 for the placement schedule.) Tape recorders were placed successfully (i.e. without malfunction) close to an active bowl on 57 occasions over 34 nights (i.e. two tape recorders put out on the same night), and kakapo vocalisations were recorded on 46 of the 57 occasions.

Booming was first recorded on 20 December. Intense and persistent booming was recorded at active sites over an 83-day period from 26 December to 18 March. Occasional and short bouts of booming were recorded as late as 27 March.

Between 18 December and 25 December five recordings were obtained. These were primarily skrarking, but there was some chinging on two recordings, and a short period of subdued booming was recorded on the night of 20 December. From 26 December onwards intense persistent booming was present on all successful recordings at active booming sites until 16 February when recording was discontinued for a four week period. Intense and persistent booming was usually accompanied by varying amounts of skrarking and chinging.

During the period 15 March to thirteen recordings were obtained but persistent booming occurred on only one (18 March). Recordings during this period were mostly skrarking, with a little chinging, some grubbing noises and very short bursts of booming.

There may be differences between the calling pattern of individuals, but insufficient recordings were obtained to resolve any differences. It should be noted that minor variations in the location and settings of the tape recorders influence recording threshold and thus compromise any comparisons of booming bout intensity and duration between recordings even at the same site.

3.1.3 Booming heard at night from distant locations
On four occasions persistent booming was heard at night in the distance coming from the direction of booming site 19:
- heard from c. 300 m a.s.l. on Track 3, 21.15 hr 27 January to 01.15 hr 28 January, 4.00 hr 28 January and 17.15 -23.00 hr 9 February.
-heard from c. 300 m a.s.l. on the Thumb Track 20.00 hr 6 February.

3.1.4 Daytime booming
Booming was heard during the day by observers in the process of inspecting booming sites and replenishing feeding stations. It is possible that daytime booming was prompted by observer disturbance. Generally daytime booming occurred close to active booming sites, was subdued and lasted only a few minutes. Exceptions to this pattern were:
- 8.30 hr 9 February; booming was heard from c. 300 m a.s.l. on the Thumb Track. Booming was persistent and appeared to come from Booming Site 9.
-16 January; daytime booming persisted for one and half hours close to Booming Site 8.
- 5 January; skrarking was heard in association with booming close to Booming Site 7.

Daytime booming was heard on 26 occasions on a total of 20 days. All but three occurrences were in the vicinity of booming sites 7, 8 and 9, where observer activity was concentrated. Daytime booming was first heard on 25 December 1989 and last heard 21 March 1990. This 87 day period corresponds closely to the period 26 December to 18 March during which intense and persistent booming was recorded using tape recorders at booming sites.

Table 1. The frequency of occurrences of daytime booming, 1989 - 1990

Period	Observer	No. of occurrences
20 Dec - 3 Jan	A	5
4 Jan -18 Jan	B	4
19 Jan -31 Jan	C	3
1 Feb -13 Feb	A	7
14 Feb - 28 Feb	B	1
1 Mar -13 Mar	D	2
14 Mar -27 Mar	A	3

Table 1 shows the frequency of occurrence of daytime booming during two-week periods throughout the booming season. Differences between periods are apparent but probably reflect variation between observers rather than between period differences in

the frequency of daytime booming. Daytime booming was heard at all hours between 0800 and 1930, the actual distribution of time of observations probably reflects observer opportunity. Daytime booming was heard in all weather conditions; including hot, sunny and dry days. Although most observations were on misty overcast days the data are insufficient to infer any association between daytime booming and misty, overcast days.

3.1.5 Identifying males at booming sites

An attempt to determine the identity of males associated with all active booming sites failed as the work was delayed until after the peak of activity at booming sites. Only five males were caught, all of these were known males (Table 2).

Table 2. The identity of males captured near active booming sites during 1990.

Date	Name	Booming site
26 Feb	Barnard	12
8 Mar	Snark	49
8 Mar	Arab	8
11 Mar	Luke	9
11 Mar	Snark	49
12 Mar	Joe	33
13 Mar	Barnard	7

3.1.6 Feathers

Figure 2. The number of kakapo feathers found each day on Little Barrier Island during the period 21 Nov - 10 Apr 1990.

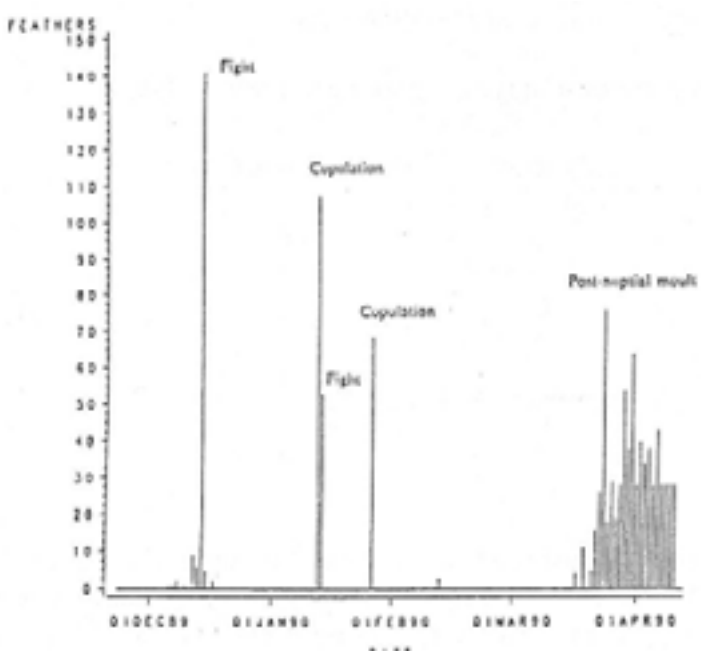


Figure 2 shows the number of feathers found each day by observers carrying out routine duties during the period 21 November 1989 to 10 April 1990. Between 20 November and 6 December no feathers were found. Between 6 December and 17 March there only occasional feathers picked up at or near booming sites, but there were four times when clusters of feathers were found:

- 14 December, Booming Site 7 96 down feathers and 45 contour feathers were found scattered over a wide area around the booming site, on the ground and caught in the surrounding scrub. The feather cluster was assumed to be evidence of a fight between birds.
- 13 January, Booming Site 24 100 down feathers and 8 contour feathers were found ground into the substrate in a small area 2 m from the bowl. The feather cluster was assumed to be evidence of a copulation attempt.
- 14 January, Booming Site 8 22 down feathers and 31 contour feathers were found in an area extending over 20 m from the bowl. Many of the contour feathers were broken. The feather cluster was assumed to be evidence of a fight between birds.
- 27 January, Booming Site 7 69 down feathers were found ground into the substrate in a 0.1 m^2 patch less than 2 m from the bowl. The feather cluster was assumed to be evidence of a copulation attempt.

From 17 March onwards there was a gradual increase in the numbers of feathers found in or near booming sites, probably as a consequence of the onset of post-nuptial moult. On most days during this period observers walking along the track from booming sites 9 to 7 collected between 10 and 40 feathers. These were mostly down feathers in small groups, but occasionally contour feathers and later on remiges were found. The increase in the number of feathers coincided with an increase in the number of kakapo faeces found along this section of track.

3.1.7 A summary of booming seasons on Little Barrier Island 1982 – 1990

Table 3 is a summary of booming on Little Barrier Island during the seven summers since kakapo were released on the island. For the first three summers after the transfers (1982/83, 1983/84 and 1984/85) monitoring male courtship behaviour was incidental to other work. Since the summer of 1985/86, there has been systematic monitoring of male courtship behaviour at booming sites each summer (Moorhouse 1986, Handford 1987, Dowding 1988 and Greene 1989). It should be noted that differences in the monitoring regimes, and their interpretations of data mean that direct comparison of the results from different years are not entirely valid.

Table 3. Booming on Little Barrier Island between 1982 and 1990.

Summer	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Booming	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Estimated number of males at peak of booming season	0	3-5	c. 8	> 7	3-5	7-8	9	11-13
Start of courtship activity	.	?	?	Early Jan	Early Dec	Early Jan	Early Jan	Late Dec
End of courtship activity	.	Mid Apr	Mid Apr	Mid Apr	Late Jan	Mid-Mar	Mid-Mar	Mid-Apr
* Copulation feathers	No	No	No	No	No	No	No	Yes

* Copulation feathers are defined as described in section 3.1.6.

3.2 Female breeding activity

3.2.1 Evidence of copulation

Clusters of feathers, interpreted as indicating copulation had occurred, were found at Booming Sites 24 and 7 on 13 and 27 January respectively (see section 3.1.6 for details).

3.2.2 Locating and monitoring nests

Two of the four females tracked using dogs during this breeding season were found to have nests with eggs (Heather and Maggie). It has been assumed that the other two females,Bella-Rose (captured on 19 February) and John-Girl (captured on 3 April), did not attempt to breed this season as they did not appear to have nest or brood patch when captured.

Heather's nest was found on 19 February. The nest was in a hole in a bank and contained a single egg. The nest was not visited by us again after its initial discovery until 21 March, when we became concerned that the nest had failed, as Heather had begun feeding at a feeding station 500 m distance from the nest instead of the feeding station 200 m from the nest. A decomposing chick was recovered from the nest on 21 March, when it was estimated that the chick had been dead for approximately seven days. The carcass was complete but flattened into the nest lining as if it had been brooded for some time after death. There was no sign of rodent attack. The carcass was examined by G.W. de Lisle (Ministry of Agriculture and Fisheries, Animal Research Centre), but autolysis was too far advanced to determine the cause of death. It is estimated that the chick hatched about 8 March and died when approximately six days old on about 14 March. If it is assumed that there was a 10 day pre-lay period between copulation and egg laying and a 25 day incubation period (Powlesland et al., in prep.) copulation probably occurred on about 1 February and the egg was probably laid some time near 11 February. The estimated date of copulation is in accord with the evidence of copulation at Booming Site 7 on 27 January.

Maggie's nest was found on 12 March. The nest was in the horizontal hollow section of the trunk of a puriri (*Vitex lucens*). The nest was dry with the entrance 600 mm above the ground. Only one egg was visible but there may have been more eggs present.

When the nest was next visited, on 28 March, it had been abandoned. The abandoned nest contained a single undamaged kakapo egg and some eggshell fragments.

G.W. de Lisle examined the egg. There was no embryonic development apparent in the egg, which may have been either infertile or have died at an early stage. Pathogens could not be detected. The egg's dimensions (length 47.2 mm, width 36.3 mm and weight 27.7 g) were compared with egg dimensions provided by Powlesland et al. (in prep.). This egg was smaller than any of the eight kakapo eggs collected from Stewart Island recently (length 48.5-55.5 mm, width 37.5-39.5 mm) but within the range of dimensions of a sample of kakapo eggs held at museums (length 45.5-60.0, N = 18; width 35.1-39.4 mm, N = 21).

The egg-shell fragments were found mixed into the litter on the floor of the nest. The fragments were small (the largest was < 25 mm^2 in area) and had membrane adhering to them. It could not be determined whether the shell fragments are from this nesting attempt nor whether they are from a kakapo egg.

A small number of mites were present in the nest, but not in sufficient quantity to threaten its viability. The mites belong to an unnamed species, the only other record being from a kakapo on Stewart Island (pers. comm. Allan Heath, Ministry of Agriculture and Fisheries, Wallaceville Animal Research Centre).

Both nests were abandoned during a period of unusually cold and wet weather, but there is no evidence to indicate that these conditions caused the nest failures.

The cause of failure could not be determined for either nest.

3.2.3 Evidence of breeding behaviour from supplementary feeding data

It may be possible to deduce some aspects of female breeding behaviour from the pattern of their visits to feeding stations. See Powlesland and Lloyd 1990 for details of the feeding programme.

Table 4. Breeding behaviour in relation to supplementary feeding.

Heather -		
Late Oct 29 Jan	Non-breeding	Feeding regularly at one or more of Site A & Site B
30 Jan 12 Feb	Courtship and pre-lay	Only 2 possible visits to Site B
13 Feb - 4 Mar	Incubation	Feeding irregularly at Site B with intervals of 1 or 2 nights between visits
5-16 Mar	Brooding chick	Feeding nightly at Site B except for one night at Site A
17 Mar -	Breeding abandoned	Feeding nightly at Site A
Maggie		
Late Oct – 31 Dec	Non-breeding	Feeding nightly
1 Jan -22 Jan	?	Feeding irregular with intervals of one or two nights
22 Jan - 5 Feb	Courtship and pre-lay	No Visits
6 Feb - 16 Mar	Incubation	Irregular visits with intervals of one or two nights
17 March -	Nest abandoned	Feeding nightly

3.2.4 Estimated breeding chronologies

All the available data, including copulation feathers, recorded nest details and females' visits to feeding stations, were used to estimate breeding chronologies for the two nesting females (Table 5).

Table 5. Summary of estimated chronology for the two nesting females.

	Maggie	Heather
	Date	Date
Event		
Copulation	22 Jan	1 Feb
Egg lay	3 Feb	11 Feb
Hatch	-	8 Mar
Chick death	-	14 Mar
Nest abandoned	17 Mar	17 Mar

3.3 Rat index trapping

Table 6. Results of rat index trapping, 1989-90.

Date	Total captures	Juv (< 45 g)	Sprung	Capt/100 nights
18-20 Nov '89	24	0	4	9.4
25-27 Jan '90	11	0	1	4.2
23-25 Mar '90	43	7	-	17.4*
12-14 May '90	63	2	31	27.5

* Number of sprung traps not recorded; an estimate was used.

4. DISCUSSION

A number of issues with consequences for future management of kakapo on Little Barrier Island emerge from the results of this investigation.

4.1 Female breeding activity

The discovery of kakapo nests on Little Barrier Island demonstrates that the stimuli which initiate breeding in female kakapo are not unique to southern New Zealand (e.g. high-latitude photoperiod cycle or the phenological development of southern plant species).

The poor breeding performance by females may be interpreted as indicating that nutrition available to female kakapo on Little Barrier is insufficient to sustain successful breeding. Although at least six females survive on Little Barrier Island, evidence of only two copulation attempts was found at booming sites. Only two of the four females

examined this season appear to have attempted to nest. One of these nests contained a single egg which hatched but the chick died soon after hatching. The original clutch size in the second nest was not established, but when the nest was inspected after desertion there was a single small and non-viable egg left.

Because the two females with nests were the only females taking supplementary food regularly before the breeding season, it is tempting to posit that the supplementary feeding programme begun in September 1989 and carried out concurrently with this investigation prompted nesting. Unfortunately, our data are inadequate to establish causality for this observed coincidence of nesting and supplementary feeding.

4.2 Number of males present

Thirteen males were transferred to Little Barrier Island in 1982. Following the known death of one male in 1983, the maximum number of translocated males surviving is twelve. Surveys in 1986 (Veitch 1986) and 1989 (Hodsell 1989) established that a minimum of ten and six males were alive in those years respectively. During previous booming seasons the maximum number of males recorded as active at booming sites was eight. Thus the estimate of between eleven and thirteen males active at booming sites this season is anomalous. It may be a consequence of either a high level of survival by the translocated males (100% over eight years), or recruitment to the population, or an error in the estimate. An attempt to resolve this question by capturing males associated with active booming sites failed, as the work was delayed until after the peak of activity and only five males were caught, all known males.

4.3 Recruitment to the Little Barrier Island population

The estimate of between eleven and thirteen booming males present on Little Barrier Island raises the possibility that males produced on Little Barrier Island may have been recruited into the breeding population. Is this possible? There is a paucity of unequivocal information on the age at which male kakapo achieve sexual maturity. The best information available (from observation of only two individuals, Lionel and Snark) indicates that males first exhibit courtship behaviour between three and five years after leaving the nest. Presumably the actual age being determined by the first occurrence of a 'booming' year after the male achieves sexual maturity. These observations are in accord with Forshaw (1978) who states, "The age at which parrots reach sexual maturity varies, but in general it is three or four years in the larger species...". Thus a young male kakapo produced during the previous major booming season on Little Barrier Island in could have reached sexual maturity by 1989. The failure to find evidence of copulation during the booming seasons does not prove that copulation and nesting did not occur during that season. The short duration of peak activity observed on Little Barrier this summer is consistent with the presence of newly recruited males as first attempts at breeding activity are likely to be of limited duration.

4.4 Monitoring booming

Placing voice-activated tape recorders at booming sites proved an effective method to monitor booming. The method minimised disturbance at the booming sites and reduces observer effort considerably. We hope to enhance the value this method by incorporating a timing device into the tape recorders to provide the time and date of recordings.

4.5 Kiore abundance

The results of the rat index trapping indicate that kiore were relatively abundant and increasing during the kakapo nest period. Despite this, there is no evidence implicating kiore in either of the two nest failures.

5. ACKNOWLEDGEMENTS

We would like to acknowledge the assistance of all the DOC staff and volunteers whose efforts have made this study possible. Special thanks go to Terry Greene for his unfailing assistance and 'Dobbie' and Mike Dobbins who have looked after both us and the island so capably.

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APPENDIX

The results of monitoring booming sites used during the 1989/90 booming season

Key:

.	- Not visited, probably not active
?	- Not visited, system probably active
0	- No disturbance since last visit
1	- Recent disturbance
2	- Slight disturbance since last visit
3	- Active since last visit
9	- disturbance but probably petrels
t	- denotes tape recording of activity at the bowl for the preceding night

System -	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Site ---	10	9	8	49	7	12 41	20 19 21	24	25	46	35 45	40 26 27	33	31	17 16 18	34	47 48
DATE																	
21NOV89	0	?	3	.	.	. .	. ? .	.	.	.	. .	. . ?	.	?	. ? .	1	. .
22	0	3	3	.	0	. .	0 2 0	0	0	.	0 0	0 0 1	.	?	. ? .	0	. .
23	0	0	0	.	.	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .
24	0	0	0	.	0	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .
25	0	0	3	.	.	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .
26	0	0	3	.	0	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .
27	0	0	2	.	.	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .
28	.	0	3	.	.	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .
29	.	0	2	.	0	. .	0 0 0	0	0	.	0 0	0 . 2	.	?	. ? .	0	. .
30	0	0	0	.	.	. .	. . .	.	.	.	. .	. . ?	.	?	. ? .	0	. .

continued

Appendix continued.

System -	1	2	3	4	5	6	7		8	9	10	11	12			13	14	15		16	17	
								20							40				17			
Site ---	10	9	8	49	7	12	41	19	21	24	25	46	35	45	26	27	33	31	16	18	34	47	48
DATE																							
01DEC89	0	0	2	.	0	0	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
02	0	0	3	.	?	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
03	.	0	3	.	?	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
04	0	0	0	.	3	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
05	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
06	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
07	0	0	3	.	0	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
08	0	3	2	.	0	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
09	0	2	0	.	0	.	.	.	.	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
10	0	0	0	.	0	.	.	0	0	0	.	0	0	1	1	1	0	1	.	?	.	3	.	.
11	0	0	0	.	0	0	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
12	0	0	0	.	0	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
13	0	0	0	.	3	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
14	0	0	2	.	3	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	0	.	.
15	0	2	0	.	3	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	2	.	.
16	0	3	2	.	3	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
17	0	3	0	.	3	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	3	.	.
18	0	0	3	.	3	.	.	.	?	.	.	.	.	.	.	?	.	?	.	?	.	2	.	.
19	0	3	0	.	3	.	.	2	3	3	0	.	0	0	3	0	3	?	.	?	.	0	.	.
20	.	3	0	.	3t	.	.	9	3t	?	.	.	.	.	.	.	.	?	.	?	.	0	.	.
21	.	0	0	.	3t	3	1	0	3	?	.	.	.	.	.	.	.	?	.	?	.	0	.	.
22	.	3	0	.	3	.	.	0	3	3	0	.	0	0	0	0	0	?	.	?	.	0	.	.
23	.	?	0	.	3	.	.	.	?	.	?	?	.	?	.	?	.	?	.	?	.	0	.	.
24	0	3	0	.	3	.	.	0	3	.	?	?	.	?	.	?	.	?	.	?	.	0	.	.
25	.	3t	0	.	3	.	.	0	0	?	?	?	.	?	.	?	.	?	.	?	.	0	.	.
26	.	3t	0	.	3	.	.	0	0	t?	?	?	.	?	.	?	.	?	.	?	.	0	.	.
27	.	3	0	.	3t	.	.	0	0	?	?	?	.	?	.	?	.	?	.	?	.	0	.	.
28	.	3	0	.	3t	.	.	.	.	?	?	?	.	?	.	?	.	?	.	?	.	0	.	.
29	.	3	0	.	3t	.	.	.	.	?	?	?	.	?	.	?	.	?	.	?	.	0	.	.
30	.	3	0	.	3	.	.	0	3	.	?	?	.	?	.	?	.	?	.	?	.	0	.	.
31	.	3t	0	.	3	.	.	.	.	?	?	?	.	?	.	?	.	?	.	?	.	0	.	.

continued

Appendix continued.

System -	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Site ---	10	9	8	49	7	12 41	19 20 21	24	25	46	35 45	26 40 27	33	31	16 17 18	34	47 48
DATE																	
01JAN90	.	3	0	.	3	. .	0 0 3	3	3	.	1 3	1 3 1	0	3	. ? .	0	. .
02	.	3t	0	.	3t	0 0	. . ?	?	?	.	. ?	. ? .	?	?	. 3 1	0	. .
03	.	3	0	.	3	. .	. . ?	?	?	.	. ?	. ? .	?	?	. ? .	0	. .
04	.	3t	0	.	3t	. .	. . ?	?	?	.	. ?	. ? .	?	?	. ? .	0	. .
05	.	3	0	.	3	. .	. . ?	?	?	.	. ?	. ? .	?	?	. ? .	0	. .
06	.	3	0	.	3	2 0	0 0 ?	?	?	.	. ?	. ? .	?	?	0 3 0	0	. .
07	.	3	0	.	3	. .	0 3 3	3	3	.	3 3	3 3 3	3	3	. . .	0	. .
08	.	3t	0	.	3t	. .	0 0 3	3	0	.	. .	. ? .	?	?	. . .	0	. .
09	.	3	0	.	3	. .	. . ?	?	.	.	. .	. ? .	?	?	. . .	0	. .
10	.	3	0	.	3	. .	. . ?	?	.	.	. .	. ? .	?	?	. . .	.	. .
11	.	3	2	.	3	0 0	0 0 3	?	.	.	. .	. ? .	?	?	0 0 0	0	. .
12	.	3	3	.	3	. .	0 0 3t	?	.	.	. .	. ? .	?	?	. . .	0	. .
13	.	3	3	.	3	. .	0 9 3	3	0	.	0 0	0 3 3	3	3	. . .	0	. .
14	0	3	3	.	3	. .	0 3 3	3	0	.	0 0	0 0 3t	3	3t	. . .	0	. .
15	.	3	3	.	3	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	0	. .
16	.	3	3	.	3	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	.	. .
17	.	3	3	.	3	0 0	. . ?	?	.	.	. ?	. . ?	?	?	0 0 0	0	. .
18	.	3	3	.	3	. .	0 0 3	3	0	.	. ?	. . ?	?	?	. . .	0	. .
19	.	3	3t	.	3t	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	0	. .
20	.	3	3	.	3	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	0	. .
21	.	3	3	.	3	. .	0 0 3	3	0	.	0 3	0 . ?	?	?	. . .	0	. .
22	.	3	3	.	3	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	0	. .
23	.	3	3	.	3	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	0	. .
24	.	3t	3t	.	3	. .	. . ?	?	.	.	. ?	. . ?	?	?	. . .	0	. .
25	0	3	3	.	3	. .	0 0 3	3	0	.	3 3	0 0 3	3	3	. . .	0	. .
26	0	3	3	.	3	. .	0 0 3	3t	0	.	2 3t	. . .	?	?	. . .	.	. .
27	0	3	3	.	3	. .	0 0 3	3	0	.	2 3	. . .	?	?	. . .	2	. .
28	.	3	3	.	3t	. .	0 0 3	3	0	.	. 3t	. . 0	3	?	. . .	0	. .
29	.	3	3	.	3	. .	0 0 3	3	0	.	0 0	. 0 0	0t	3	. . .	0	. .
30	0	3	3	.	3	. .	. . ?	?	.	.	. ?	. . .	.	?	. . .	0	. .
31	0	3	3	.	3	. .	. . ?	?	.	.	. ?	. . .	.	?	. . .	0	3 0

continued

Appendix continued.

System →	1	2	3	4	5	6	7		8	9	10	11	12		13	14	15		16	17	
								20						40				17			
Site →	10	9	8	49	7	12	41	19	21	24	25	46	35	45	26	27	33	31	16	18	34	47	48
DATE																							
01FEB90	.	3	3	.	3	.	.	.	. ?	?	.	?	.	?	.	.	.	?	.	? .	0	1	3
02	0	3	3t	.	3t	.	.	0	0 3	3	0	3	0	3	0	. 0	0	3	.	? .	0	3	3
03	0	3	3t	.	3t	.	.	.	. ?	?	.	?	.	?	.	. ?	?	?	.	? .	0	3	3
04	0	3	3	.	3	.	.	0	0 3	3	0	?	.	?	.	. ?	?	?	.	? .	0	3	0
05	0	3	3	.	3	.	.	.	. ?	?	.	?	.	?	.	. ?	?	?	.	? .	0	3t	0t
06	0	3	3	.	3	.	.	.	. ?	?	.	?	.	?	.	. ?	?	?	.	? .	0	3t	0t
07	0	3	3	.	3	.	.	.	. ?	?	.	?	.	?	.	. ?	?	?	.	? .	0	3	3
08	.	3t	3t	.	3	.	.	0	0 3	3	0	3	0	3	0	. 3	3	3	.	? .	0	3	3
09	0	3t	3t	.	3	.	.	.	. ?	?	.	?	.	?	.	. ?	?	?	.	? .	0	3	0
10	.	0	3	.	3	1	0	.	. ?	?	.	?	.	?	.	. ?	?	?	1	3 0	0	3	0
11	.	0t	3t	.	3	?	.	0	0 3	3	0	?	.	?	.	. ?	?	?	.	? .	0	3	0
12	0	0t	3	.	3t	3	.	0	0 3	3	0	3	0	3	0	0 3	?	?	3	3 0	0	3	0
13	0	3	3	.	3	?	.	.	. ?	?	.	?	.	?	.	. ?	?	?	.	? .	0	3	0
14	0	3	3	.	3	3	0	.	. ?	?	.	?	.	?	.	. ?	?	?	0	3 0	0	3	0
15	.	3	3	.	3	3	.	0	0 3	3	0	2	0	3	0	0 3	3	3	0	3 0	0	3	0
16	.	3	3	.	3	3	0	0	0 3	3	0	0	0	3	0	0 0	3	3	0	3 .	0	3t	0
17	0	3	3	.	3	?	.	.	. ?	?	.	.	.	?	.	. ?	?	?	.	? .	0	0	0
18	0	3	3	.	3	?	.	.	. ?	?	.	.	.	?	.	. ?	?	?	.	? .	0	0	0
19	0	3	3	.	3	?	.	.	. ?	?	.	.	.	?	.	. ?	?	?	.	? .	0	0	0
20	0	3	3	.	3	?	.	.	. ?	?	.	.	.	?	.	. ?	?	?	.	? .	0	0	0
21	0	3	3	.	3	3	.	0	3 3	3	0	0	0	3	0	0 3	3	3	2	3 0	0	0	0
22	0	3	3	.	3	?	.	0	2 3	0	0	0	0	0	0	0 3	?	?	.	? .	0	0	0
23	0	3	3	.	3	?	.	0	3 3	2	0	0	0	0	0	0 3	?	?	.	? .	0	0	0
24	0	3	3	.	3	3	.	0	0 3	?	?	.	.	?	.	. ?	?	?	2	3 0	0	0	0
25	.	3	3	.	3	?	.	.	. ?	?	?	.	.	?	.	. ?	?	?	.	? .	0	0	0
26	.	3	3	.	3	3	.	.	. ?	?	?	.	.	?	.	. ?	?	?	2	3 0	0	0	0
27	.	3	3	9	3	?	.	.	. ?	?	?	.	.	?	.	. ?	?	?	.	? .	0	0	0
28	.	3	3	3	3	?	.	.	. ?	?	?	.	.	?	.	. ?	?	?	.	? .	0	0	0

continued

Appendix continued.

System -	1	2	3	4	5	6	7		8	9	10	11	12		13	14	15		16	17	
	10	9	8	49	7	12	41	19 20 21	24	25	46	35	45	26 40 27	33	31	16 17 18		34	47	48
DATE																					
01MAR90	0	3	3	0	3	.	.	. . .	.	.	.	.	.	. . .	?	?	. ? .		0	0	0
02	0	3	3	0	3	3	0	0 3 3	3	3	0	0	3	0 0 3	3	3	0 3 0		0	0	0
03	0	3	3	9	3	3	0	2 0 3	3	2	0	0	3	0 0 0	0	3	0 3 0		0	0	0
04	0	0	3	0	3	?	.	. . ?	?	?	.	.	.	. . ?	?	?	. ? .		0	0	0
05	0	0	3	0	3	3	.	0 0 3	3	3	0	0	0	0 0 3	?	?	0 3 0		0	0	0
06	0	0	0	0	0	?	.	. . ?	?	.	.	.	?	. . .	?	?	. ? .		0	0	0
07	0	0	3	0	3	?	.	0 0 3	3	0	0	0	3	0 0 0	3	3	. ? .		0	0	0
08	0	0	3	0	3	?	.	. . .	?	.	.	.	.	. . .	.	?	. ? .		0	0	0
09	0	0	3	0	0	?	.	. . .	?	.	.	.	.	. . .	.	?	. ? .		0	0	0
10	0	3	3	0	0	?	.	. . .	?	.	.	.	.	. . .	.	?	. ? .		0	0	0
11	0	0	3	0	0	?	.	. . .	?	.	.	.	.	. . .	.	?	. ? .		0	0	0
12	0	0	0	0	0	?	.	0 0 0	3	0	0	0	0	0 0 0	0	2	. ? .		0	0	0
13	0	3	0	0	0	?	.	0 0 0	0	3	0	0	0	. . .	.	?	. ? .		0	0	0
14	.	0	0	0	0	?	.	. . ?	.	.	.	.	.	. . .	.	?	. ? .		0	0	0
15	.	3	0	0	0	?	.	. . ?	.	.	.	.	.	. . .	.	?	. ? .		0	0	0
16	.	0t	0	0	0	3	0	. . ?	.	.	.	.	.	. . .	.	?	0 3 0		0	0	0
17	.	3	0	0	3	0	.	. . ?	.	.	.	.	.	. . .	.	?	0 0 0		0	0	0
18	0	2t	0	.	3	?	.	0 3 3	0	0	0	0	0	0 0 0	0	3	. . .		?	.	.
19	.	0t	0	3	3t	?	.	. . ?	?	?	.	.	?	. . .	.	.	. . .		3	0	0
20	.	0t	3	3	0t	?	.	. . ?	?	?	.	.	?	. . .	.	.	. . .		0	0	0
21	.	3	3	3	3	?	.	. . ?	?	?	.	.	?	. . .	.	.	. . .		0	0	0
22	0	3	3	3	3	?	.	. . ?	?	?	.	.	?	. . .	.	.	. . .		0	0	0
23	0	0t	3	3	0t	3	.	. . ?	?	?	.	.	?	. . .	.	.	0 0 0		0	0	0
24	3	0	3	3	3	?	.	9 3 3	3	3	0	0	3	0 0 0	.	.	. . .		0	0	0
25	0	3t	3	3	3t	?	.	. . ?	.	.	.	.	.	. . .	.	.	. . .		0	0	0
26	0	3	3	3	3t	?	.	. . ?	.	.	.	.	.	. . .	.	.	. . .		0	0	0
27	0	3	3	3	3	?	.	. . ?	.	.	.	.	.	. . .	.	.	. . .		0	0	0
28	0	0	0t	2	0t	?	.	. . ?	.	.	.	.	.	. . .	.	.	. . .		0	0	0
29	0	0	0	0	0	?	.	0 2 2	.	.	.	.	.	. . .	.	.	. . .		0	0	0
30	.	3	0	0	0	?	.	0 3 0	.	.	.	.	.	. . .	.	.	. . .		0	0	0
31	.	0	2	2	2	3	3	. . .	.	.	.	.	.	. . .	.	.	. . .		0	0	0

continued

Appendix continued.

System -	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Site ---	10	9	8	49	7	12 41	20 19 21	24	25	46	35 45	40 26 27	33	31	17 16 18	34	47 48
DATE																	
01APR90	.	0	0	9	0	0 0	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
02	0	0	3	0	0	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
03	.	0	3	0	3	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
04	0	0	3	2	3	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
05	.	0	0	0	0	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
06	.	.	0	2	0	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
07	.	0	2	2	0	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
08	.	0	0	.	2	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0
09	0	2	0	0	2	. .	. . .	.	.	.	. .	. . .	.	.	. . .	.	. .
10	.	2	2	0	0	. .	. . .	.	.	.	. .	. . .	.	.	. . .	0	0 0