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KAKAPO BREEDING ACTIVITY ON LITTLE BARRIER ISLAND: OCTOBER 1990 – JUNE 1991

by

B.D. Lloyd and R.G. Powlesland

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**Science and Research Division, Department of Conservation,
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ABSTRACT

Breeding activity by kakapo on Little Barrier Island was monitored throughout the period October 1990 to June 1991. Booming began in early October, two months earlier than previously recorded, and continued until mid-April. At the height of the booming season ten males were booming. Four of the five females taking supplementary food nested during late January. Two of the nests were successful, each fledging a single chick in late May. Both fledglings survived to independence.

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, occurred on Little Barrier Island during five of the seven summers (1982-1989) following the transfers, but we suspect that nesting did not occur during this period as there was no evidence of copulation at the males' booming sites (i.e. display sites, also known as track and bowl systems), 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). In September 1989 a programme to promote breeding by providing dietary supplements to free-living kakapo on the island was begun. During that summer (December 1989 to April 1990) male kakapo displays were the most intense and extended ever recorded, and the first two kakapo nests recorded on the island were discovered (Lloyd and Powlesland 1990).

This report describes the results of a programme to monitor breeding behaviour of kakapo on Little Barrier Island during the period October 1990 to June 1991.

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 described by Moorhouse 1986, Handford 1987, Dowding 1988, and Greene 1989. During this study these methods were used with the modifications described in Lloyd and Powlesland 1990.

2.1.1. Monitoring of disturbance at booming sites

All known booming sites were inspected repeatedly throughout the period 10 October 1990 to 19 April 1991. The regularity of inspection varied from daily, for conveniently located active sites, to monthly, for remote or 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. Details of any booming heard were also recorded.

2.1.2 Monitoring booming

Small voice-activated tape recorders were left at booming sites overnight. Olympus miniature tape recorders (models L100, L200 and S930) were used with C60 tapes. A tape recorder was wrapped in two small plastic bags, switched to voice activated mode and placed in a small hole (usually dug in a peat bank) within 200 mm of a bowl. Recordings were made 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, to both speed up the playback process and make booming audible on the tape recorder's small loudspeakers. Any sounds which could be attributed to kakapo (i.e. booming, skraaking and chinging calls, and grubbing noises) were noted. A description of these calls can be found in Powlesland *et al.* in press.

2.1.3 Identifying males at booming sites

Males were identified either by catching them at night in cage traps sited near active booming sites, or during the day by using trained dogs to track them from their booming sites to daytime roosts. Males with patterns painted on the stainless steel leg band could be identified without handling, otherwise it was necessary to handle the birds to read the band number. Identifications were undertaken at the beginning and end of the booming season to avoid interfering with actual courtship.

2.1.4 Feather clusters at booming sites

Clusters of kakapo feathers found at booming sites may be the result of either copulation Powlesland (1989) or fighting. Whenever we visited booming sites we therefore examined the surrounding area for feathers. 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 (<5 m); the feathers were mixed into the substrate and were primarily down feathers. In contrast, clusters of feathers considered to be the result of fighting were scattered over several metres; they were usually more than five metres from active bowls; they were not mixed into the substrate and many were contour feathers.

2.1.5 Feather counts

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

2.2 Female breeding activity

2.2.1 Monitoring female movements using radiotelemetry

Four females were fitted with miniature radio-transmitters (supplied by Sirtrack NZ and weighing c. 30 g each) during October and November 1990, prior to this breeding season. A fifth female was caught at a nest while brooding chicks, and radiotagged on 31 March 1991. Capture details are in Appendix A. The locations of radiotagged females were monitored remotely by radio-triangulation every few days. This allowed us to identify movements to courtship areas, copulation and nesting.

2.2.2 Monitoring nesting

When nesting was suspected the radiotagged females were approached both to confirm the nesting attempt and to locate the nest for intensive monitoring. Three nests belonging to radiotagged females were located during daylight when the females were sitting.

Subsequent inspections were made at night when the female was off the nest. In order to do this we arrived c.100 m from a nest just before dusk and monitored the direction and strength of the female's radio-signal until she was well away from the nest.

A fourth nest, which belonged to a female without a radio-transmitter, was located using a trained dog. This nest was regularly inspected during daylight with the female present until mid-way through brooding when she was radiotagged. Subsequent nest inspections were made at night as with other nests.

Nests were generally inspected four or five times during the incubation period. During the first half of the brood period nests were inspected at three day intervals and during the latter half of the brood period nests were inspected at intervals of four to five days.

Egg Data
Eggs were candled at the nest. Weight, length and maximum diameter were recorded.

Determining egg temperatures
Incubation temperatures were obtained from two nests using a temperature sensitive artificial egg. A temperature sensitive transmitter (obtained from Sirtrack, NZ) was embedded in paraffin wax in an artificial bantam's egg. The transmitter's pulse period, which varied with temperature, was measured remotely at distances of up to 50 m using a Telonics TDP Data Processor connected to the output from a Telonics TR2 receiver with a standard hand-held Yagi antenna. The system was calibrated by placing the egg in a controlled temperature incubator with a thermometer and recording pulse rates over a range of temperatures. The egg was placed in the nest with the real clutch at night the female was away from the nest.

Chick development
Because access to one of the two successful nests was difficult, most observations of chicks were made at only one nest. During each inspection the chick was weighed and a written description made of its plumage, mobility, physical co-ordination and vocalisation. Photographs were taken regularly. Tarsus length, culmen length and width were all recorded occasionally. Primary feather development was monitored by recording the lengths, in millimetres, of both the sheathed region and the unfurled vane of the ninth primary from the inside (that is fourth from the outside) of the right wing.

The movement of fledglings
Miniature radio-transmitters, weighing c. 30 g, were fitted to the chicks a few days before they left the nest. The location of both fledglings and the females was then determined every few days by remote radio-triangulation.

2.3 Rodent control around nests

To reduce the possibility of the predation of chicks by kiore (*Rattus exulans*), rodents control was undertaken around nests. The control method was previously tested around kakapo feeding stations on Little Barrier and is fully described in Powlesland and Lloyd 1992. Six covered bait silos (McFadden 1984) were placed at equal distances on a circle of 50 m radius around each nest during the incubation period. Initially non-toxic prebait (green-dyed kibbled maize) was placed in the silos hut after c. 10 days the pre-bait was replaced by toxic bait (0.005% by weight in green-dyed kibbled maize). The toxic bait was replenished regularly until the silos were removed just before the kakapo chicks left the nests.

2.4 Supplementary

As part of a concurrent supplementary feeding programme, described in Powlesland and Lloyd (1990, 1992), kakapo were provided with dietary supplements. Feeding stations were placed within the home ranges of the five known females and within 50 m of several active booming sites (Sites 7,8,9 and 21). Evidence of feeding by kakapo at these stations was recorded daily. A full account of this work can be found in Powlesland and Lloyd (1992).

2.5 Rat index trapping

Changes in the abundance of rats were assessed by using a rat index line operated for three consecutive nights at two-month intervals (Lloyd and Powlesland, 1990). Two Ezeset rat raps were placed under aluminium covers at each of 45 sites located at 50 m intervals on Track 20 from approximately 150 m a.s.1. to 650 m a.s.1.. Traps were baited with cheese.

3. RESULTS

3.1 Male breeding activity

3.1.1 Monitoring disturbance at booming sites

At the end of the 1990-91 breeding season there were 50 known booming sites on Little Barrier Island, including one new site found in December 1990. Disturbance attributed to kakapo was detected at 31 of the 50 known sites during the period 1 October 1990 to 30 April 1991. The results of monitoring disturbance at the 31 active sites during this period are provided in Appendix B.

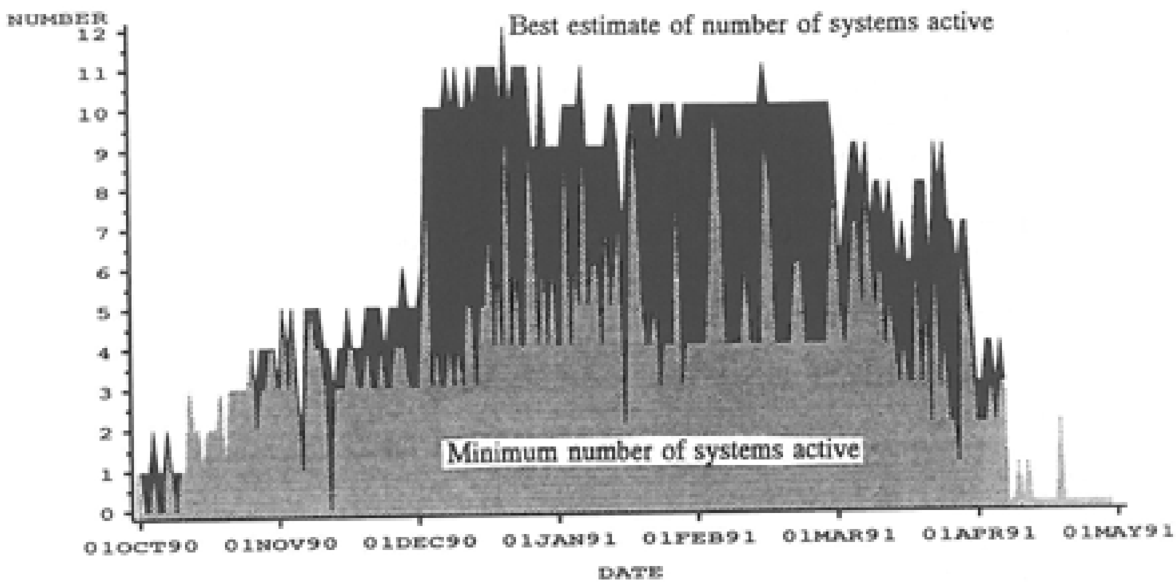
Figure 1 is a graph of the numbers of systems used by kakapo each night during the period 1 October to 30 April. We estimate that during the 1990-91 booming season up to ten males were active at booming sites during a 190-day period from 1 October 1990 to 8 April 1991, and that there were 1357 active system-nights. In comparison, we estimate that during the 1989-90 season there were 11 to 13 males active during a 140 day period from 21 November 1989 to 10 April 1990, and that there were 964 active system-nights.

Activity was first noted on 1 October 1990 during our first inspection of booming sites when one site (Site 21) was found to have been disturbed. By mid-October four systems were regularly active. A fifth system became active towards the end of October. Sometime between 20 November and 3 December a further 5 systems became active, bringing the number of regularly active systems to 10. During the period 3 December 1990 to 1 March 1991 activity was recorded at between 7 and 12 systems each night, the modal value being 10. It is probable that there were only 10 males active, the extra two systems being the result of individuals being active at more than one system in one night. From 1 March onwards the number of active systems declined steadily until by 8 April activity had ceased almost entirely, though there was sporadic activity at three systems between 8 and 19 April.

Seasonal changes in the patterns of disturbance observed at booming sites were similar to those described for the 1989-90 season in Lloyd and Powlesland (1990).

Figure 1. The number of booming systems used each night on Little Barrier Island during the period 1 Oct 1990 – 30 April 1991.

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.



3.1.2 Monitoring booming using tape recorders

Tape recorders were placed at booming sites during the period 9 October 1990 to 8 April 1991, most commonly at Sites 7, 8 and 21. Tape recorders were placed successfully (i.e without malfunction) close to an active bowl on 60 occasions, and kakapo vocalisations were recorded on 47 occasions.

Booming was first recorded at Site 21 during October. Initially on 9 and 11 October booming was soft and intermittent but on 21 October intense and persistent booming was recorded.

Skraaking but not booming was recorded at Site 7 on 17 and 18 November. Skraaking with some booming was recorded at Site 8 on 28 October but it was not until 23 November that strong and persistent booming was recorded from sites other than Site 21. From 23 November 1990 to 9 March 1991 strong and persistent booming was recorded on 33 of 35 recordings made at active sites. During this period short bursts of skraaking in the middle of booming were recorded on three occasions and chinging was recorded once (at Site 24 on 7 January 1991). Booming seemed to subside during mid-March; the last booming recorded (occasional short bouts) being on 27 March at Site 21.

3.1.3 Booming heard at night

24 February: An observer 50 m south of Site 7 saw a kakapo go past at 20.45. Subsequently booming was heard from both Sites 7 and 8 from 21.45 to 6.00. Skraaking and one bout of chinging was heard from Site 8.

25 February: An observer 50 m south of Site 7 heard several males booming from 21.00 to 6.00. It seemed as if one male boomed at Site 49 21.00 to 21.30 and then moved to Site 7 where it boomed for the rest of the night.

5 March: An observer 100 m east of Site 24 heard booming begin at Site 24 at 21.45. Booming was still strong at 24.00. There was no activity at Site 24 after 21.50.

12 March: An observer 100 m east of Site 24 heard skraaking between 20.252-20.35. There was intermittent booming from surrounding booming sites from 20.30 onwards all night.

3.1.4 Daytime booming

Booming was heard during the day by observers inspecting booming sites and replenishing feeding stations. It may have been prompted by observer disturbance. Daytime booming generally occurred close to active booming sites, was subdued and lasted only a few minutes. It was heard on 43 occasions on a total of 32 days over a 132 day period lasting from 24 November 1990 to 5 April 1991. Most occurrences were between Booming Sites 7 and 21 where observer activity was concentrated.

Table 1. The frequency of occurrence of daytime booming, 1990 - 1991.

Fortnight Starting	No. of occurrences
20 Nov	3
4 Dec	2
18 Dec	6
1 Jan	14
15 Jan	7
29 Jan	4
12 Feb	0
26 Feb	4
12 Mar	1
26 Mar	2

Table 1 shows a pronounced peak in daytime booming frequency during early January, which probably reflects a peak in courtship activity. Daytime booming was heard at all hours between 10.00 and 18.00; the actual distribution of time of observations probably reflects observer opportunity. It was heard in all weather conditions; including hot, sunny and dry days.

3.1.5 Identifying males at booming sites

During the 1990-91 breeding season five males were caught near booming sites (Table 2). Capture details of all birds caught and handled during the 1990-91 season are in Appendix A.

Table 2. The identity of males captured near booming sites during the 1989-1990 and 1990-1991 breeding seasons.

	Site	Date	Name
1989-90	7	13 Mar 90	Barnard
	8	8 Mar 90	Arab
	9	11 Mar 90	Luke
	12	26 Feb 90	Barnard
	33	12 Mar 90	Joe
	49	8 Mar 90	Snark
	49	11 Mar 90	Snark
1990-91	7	19 Oct 90	Pegasus
	7	25 Feb 91	Pegasus
	8	19 Oct 90	Arab
	9	19 Oct 90	Luke
	21	25 Oct 90	Snark
	24	6 Apr 91	Bill

Research on Stewart Island (Powlesland *et al.* in press) indicates that male kakapo show considerable site fidelity throughout most of a booming season and between seasons, but that at the beginning and towards the end of booming seasons males may move between booming sites.

3.1.6 Feather clusters

Large clusters of feathers were found at active booming sites on seven occasions between 31 October 1990 and 23 February 1991 (Table 3). Three clusters found between 3 and 20 January were interpreted as being conclusive evidence of copulation; a fourth cluster found on 23 January 1991 may also have been the result of a copulation.

Table 3.
Feather cluster details for the period 31 October 1990 -23 February 1991.

31 October. 50 m north of Site 7: Evidence of a fight.
50 down and contour feathers, some of then damaged, were found in two clusters ten metres apart. The two clusters were scattered over areas of 100x250mm and 50x50 mm.

3 January, Site 24: Evidence of copulation.
More than 70 down feathers, large quantity of finely shredded fragments of down, and 10 contour feathers in a patch on the track 4 m west of the bowl. Much of the feather material was ground into the leaf litter.

6 January, Site 21: Not significant
15 down feathers were found caught on a root by the bowl.

14 January. Site 24: Evidence of copulation
35 down feathers and a large quantity of finely shredded fragments of down feathers were found ground into piles of leaf litter on the track 1-2 m east of the bowl. Between these piles of leaves and feathers there was an area, 140x300 mm and 800 mm from the bowl, swept clear of leaves. Heather was roosting near the booming site.

20 January. Site 7: Evidence of copulation.
67 down feathers, a large quantity of finely shredded fragments of down feathers, and 1 contour feather were found in three patches along a section of track from 1 to 4 m south of the bowl. The feather material was mixed with leaf litter. In the largest of the three patches there was a distinct ball of leaf litter and feather material. John-Girl was roosting near the booming site.

January 23, Site 49: Possibly a fight but may have been a copulation.
20 down feathers and 76 contour feathers found on the track 2 m from the bowl mixed into the soil and leaf litter. No radiotagged female known to be close by.

23 February. Site 9: Evidence of a fight.
A large number of down feathers and 6 contour feathers were found 25 m north of the bowl.

3.1.7 Feather counts

A small number of down and contour feathers were found daily throughout the booming season. In addition large clusters of feathers were found on several occasions as described in the preceding section. From mid-March onwards there was a marked increase in the numbers of feathers (both down and contour) found on the tracks near booming sites. Most feathers were found individually or in small groups but occasionally groups of 40-50 feathers were found. This increase in the number of feathers found corresponded closely with the decline in booming activity and resulted from the onset of post-nuptial moult.

3.2 Female breeding activity

3.2.1 Summary

Four of the five females monitored this season nested during late January 1991 (Maggie, John-Girl, Heather and Wendy). The chronology of the four nests is shown in Table 4 and a summary of estimates of the length of the different stages of nesting is shown in Table 5. The fifth female did not attempt to nest. Two of the four nests were unsuccessful. One of these unsuccessful nests contained a single infertile egg, the other contained one infertile egg and one fertile egg, but the fertile egg died at about 5-7 days, probably as a result of chilling. In an attempt to promote re-nesting we removed these two unsuccessful clutches during early incubation. Re-nesting did not occur. One chick fledged from each of the two successful nests during mid-May. At the time of writing both chicks survive as independent juveniles. A single fertile egg was removed from one of the successful nests during February and taken to Auckland Zoo to be reared artificially. The egg hatched successfully, but the chick died four days later as a result of a combination of digestive and respiratory infections.

All five females were feeding at supplementary feeding stations regularly for many months before the 1990-91 breeding season and continued to feed at the stations during the breeding season (Powlesland and Lloyd 1992). Brooding females took large quantities of supplementary food and some water, presumably to moisten food for regurgitation. After fledging the females and at least one of the dependent juveniles fed regularly at supplementary feeding stations. Examination of juveniles's droppings and the discovery of natural feeding sign around their roost sites indicated that the juveniles were taking natural foods as well as the supplementary food.

Table 4. Female breeding chronology

	Maggie	J.-Girl	Heather	Wendy
Copulation	10Jan*	19Jan	12-13Jan	2 Jan?
Egg laying	21Jan	28-30Jan	21-27Jan	19-25 Jan?
Hatching	.	27Feb-2Mar	.	21Feb
Fledging	.	10May	.	29Apr

* Moved towards booming sites but probably didn't copulate.

Table 5. Estimates of the lengths of nest stages in days.

	Maggie	J.-Girl	Heather	Wendy
Pre-lay	11	9-11	8-15	?
Incubation	.	31	.	?
Nestling	.	69	.	67

3.2.2 Breeding details for each female

Maggie

Summary

Maggie was caught and radiotagged on 24 October 1990. She moved towards unoccupied booming sites on 10 January but probably didn't visit an active site and there is no evidence that she copulated. We found her nest on 21 January, but did not inspect the nest until some nights later, while she was absent. There was one infertile egg laid on c. 21 January. On 29 January we replaced this infertile egg with two artificial eggs which we removed two nights later. Maggie abandoned the nest a day later on 1 February. Her location was monitored regularly throughout the rest of the breeding season but there was no evidence of further breeding attempts.

Weight

Mean weights prior to supplementary feeding = 1.15 kg (n=3 sd=0.200)
Weights recorded since supplementary feeding began:

10 Oct 89	1.60 kg
24 Oct 90	1.60 kg
13 Aug 91	1.65 kg
12 Oct 91	1.51 kg

Previous breeding history

During the 1989-90 breeding season Maggie laid one egg which was probably infertile. There was no evidence that she copulated.

Supplementary feeding

Maggie had been taking supplementary food consistently since late 1989. During the period 1-21 January 1991 she fed at the feeding station irregularly: only 13 nights out of 20, compared with 84-97% throughout the preceeding 6 months. From 22 January to 2 February, when Maggie was nesting, she fed on only 3 nights out of 11. After abandoning the nest on 1 February she fed almost nightly.

Pre-nesting movements

Maggie roosted in the area around her feeding station and subsequent nest site until 9 January 1991. Generally she roosted within a hundred metres of the feeding station. On 10 January she roosted below Booming Site 5, on the slopes of Bald Rock, approximately 2 km from her feeding station. On 12 January she was once again close to the feeding station and from then onwards she roosted in the area in which she subsequently nested.

Copulation

Maggie moved towards the old unused Booming Sites 1-6 between 9 and 11 January but probably did not approach any active sites. She may never have been close enough to any booming males to hear them. There is no indication that she copulated.

Nest log

21 January, 16.30. We found Maggie's nest but did not inspect it. During the next two nights we attempted to visit the nest while Maggie was absent, but remote monitoring (from 100 m away) indicated that Maggie stayed close to her nest and we therefore did not approach.

23 January, 21.00: While Maggie was off the nest the nest contents were inspected but not handled. There was one egg 1.2 m into the cavity, behind a 30 mm high wall of leaves.

27 January 200: While Maggie was away from the nest the egg was removed from the nest, measured, and candled. The egg was replaced together with a temperature sensor egg. At 2.20 Maggie returned to the nest and resumed incubation.

29 January, 1220: Maggie's egg and the temperature sensitive egg were removed from under her and replaced by two artificial eggs. Maggie immediately resumed brooding. Her egg was placed in a portable incubator at 95 F and flown to Auckland Zoo by helicopter.

30 January: The artificial eggs were removed from her nest at night while she was absent.

31 January: Maggie was still on her nest.

1 February: Maggie was roosting away from her nest.

Heather

Summary

Heather was caught and radiotagged on 26 November 1990. She spent five nights (12 to 17 January) close to the active booming sites 7, 8, 9, 49, 21 and 24. She copulated at Site 24 on the night of 13 January, presumably with Bill, who was captured at this site later in the season. Heather laid two eggs sometime during the period 21-27 January. One of the eggs was infertile and the embryo of the other died at about 5 days, probably as a result of chilling during a severe storm on 2 February. We removed both eggs on 3 February and Heather deserted the nest on 5 February. She did not attempt to breed again during the 1990-91 season.

Weight

Mean weights prior to supplementary feeding = 1.24 kg (n=13 sd=0.121)

Weights recorded since supplementary feeding began:

15 Nov 90	1.70 kg
26 Nov 90	1.88 kg
11 Sep 91	1.55 kg
12 Sep 91	1.59 kg
11 Oct 91	1.55 kg

Previous breeding history

During the 1989-90 breeding season Heather nested, but the nest failed when a single nestling died at about six days old during a wet, cold period.

Supplementary feeding

Heather had been taking supplementary food consistently since late 1989, but it was difficult to be certain when Heather had fed because she used two feeding stations which were both also used by other kakapo. During December 1990 she probably fed nightly at a feeding station close to her subsequent nest site. In early January she fed at this same feeding station irregularly. She ceased feeding during the period 12-19 January, when she visited males at their booming sites, but returned to feed irregularly during the pre-lay and early incubation periods. On 3 February, when we removed the two eggs from her nest, she resumed feeding nightly, probably moving between two nearby feeding stations.

Pre-nesting movements
During the period 1-8 January Heather roosted in the area around her feeding stations. On 10 January she roosted near the subsequent nest site. From 12 to 17 January she roosted in the vicinity of active booming sites: 12 January 30 m east of Site 8, 13 January close to Site 7, 14 January 10 m from Site 24, 15 January close to Site 49, 17 January 100 m below Site 49. On 18 and 20 January she had returned to Feeding Station 9 and roosted close by. From 21 January until the nest was abandoned on 5 February she roosted at her nest site.

Copulation
Heather spent five nights (12 to 17 January) close to the active Booming Sites 7, 8, 9, 49, 21 and 24. She copulated at Site 24 on the night of 13 January, presumably with Bill, who was captured in a cage trap while still booming at this site on 6 April.

Nest Log (Laying date: 21-27 January)
24 January, midday: We approached to within 5 m of the nest but did not inspect it. Heather growled as we approached.
28 January, 11.15. We inspected the nest contents. Initially we used a fibrescope but Heather attacked it, she then moved to one side revealing two eggs.
31 January, 20.30 – 1 February 2.30: We monitored Heather's movements from about 70 m away. Heather stayed on, or close to the nest throughout. We approached to within 20 m of the nest briefly to confirm her location.
3 February, 14.2: The two eggs were removed and candled; one was infertile, the other was fertile but had died 18 to 24 hours earlier on 2 February (a cold squall and a violent thunderstorm occurred at about that time). Both eggs were placed in a portable incubator at 95 F and transferred to Auckland Zoo by helicopter.
4 January: Heather was roosting in the nest
5 January: Heather was roosting away from the nest.

Wendy

Summary
Wendy's nest was found by a trained dog on 25 January 1991. Wendy was not radiotagged until 31 March when she was caught by us on the nest and radiotagged. Because she was not radiotagged early in the season we can not be sure of the details of copulation but we suspect she copulated at Site 24 on the night of 2 January with Bill. Wendy laid three eggs, probably during the period 19-25 January. Two eggs hatched c. 21 February, but the third failed to hatch and we removed it on 17 March. One chick aged c. 30 days disappeared between 22 and 25 March, when there was a period of heavy rain. The other chick (subsequently named Dobby) left the nest around 29 April approximately 68 days after hatching. Before Dobby fledged he was banded and tagged. Dobby remained in or close to his natal home-range and was observed both being fed by Wendy, and feeding from a feeding station with Wendy, during September 1991, four months after leaving the nest.

Weight
Mean weights prior to supplementary feeding = 1.31 kg (n=10 sd=0.152)
Weights recorded since supplementary feeding began:

14 Oct 89	1.85 kg
31 Mar 91	1.47 kg
14 Jul 91	1.52 kg
06 Oct 91	1.53 kg

Previous breeding history
There is no information on whether Wendy attempted to breed in the 1989-90 breeding season.

Supplementary feeding
We can not be sure whether Wendy was taking supplementary food before 31 March, when she was radio-tagged, but we believe that she was taking supplementary food irregularly through the period December to mid-February and then regularly from the final week of incubation (c. 15 February) onwards. The quantities of food taken increased for the first few weeks of chick rearing until mid-March, when one of the two chicks died; quantities then declined. Water was taken regularly from mid-April, soon after it was first provided at her feeding station. Presumably the water moistened food for regurgitation to her chick.

Pre-nest movements
There is no reliable information on her movements before nesting as she was not radiotagged until the middle of the nest period.

Copulation details
Copulation feathers were found when there was no radiotagged female nearby on two occasions: 3 January at Booming Site 24, and 23 January at Site 49. The copulation on 3 January fits Wendy's nest chronology better than the later copulation but would have entailed an unusually long pre-lay period of 17-23 days. The male at Site 24 was probably Bill, captured there in a cage trap while still booming on 6 April. Site 49 was used only occasionally during the 1990-91 season. The reduction in activity found at the closest booming site (No. 7) on 23 January indicates that the male at this site (probably Pegasus) may have moved temporarily to Site 49.

Nest log

Incubation
Five nest visits undertaken by us before hatching were all made during the daytime while Wendy was on the nest:

25 Jan: Wendy and the nest were found. No eggs were visible.
26 Jan: Nest inspected; no eggs were visible but there was a dead petrel in the nest.
27 Jan: Nest inspected with a fibrescope; one egg was visible.
29 Jan: Nest inspected with a fibrescope; two eggs visible, we removed the dead petrel.
31 Jan: Nest inspected with fibrescope; the female sat tight and we were unable to see eggs.

Brooding
(Hatching date: c. 21 February; Fledging date: 29 April, Day 67 Chick name: Dobby)

Until 31 March (Day 38) the nest was visited in daylight at approximately three day intervals. From 31 March (when Wendy was radiotagged) the nest was visited at night at intervals of 4-5 days. Because the chick was difficult to reach it was only handled three times, when the opportunities arose: Days 35 (28 Mar), 60 (22 April) and 67 (29 April).

Key visits were:

25 Feb, Day 4:	One chick and one egg visible.
4 Mar, Day 11:	Two chicks and one egg.
17 Mar, Day 24:	Two chicks; we removed the egg.
22 Mar, Day 29:	Two chicks; one slightly more advanced.
25 Mar, Day 32:	Only one chick visible.
31 Mar, Day 38:	Wendy was caught on the nest and radiotagged.
17 Apr, Day 55:	The chick was not in main nest chamber, but close to the main (back) entrance.
22 Apr, Day 60:	The chick was sitting at the back entrance. He was caught and banded KA 0135.
25 Apr, Day 63:	The chick was sitting at the back entrance to the nest.
29 Apr, Day 67:	The chick was one metre outside the nest entrance. He was caught and a radio-tagged.
6 May, Day 74:	The chick was sitting five metres outside the nest entrance.

Post-fledging

For the first 16 days after leaving the nest the fledgling (Dobby) roosted close to the female, less than 20 m from the nest. During June Wendy and Dobby generally roosted 50-100 m apart in the vicinity of a feeding station. Subsequently, although Dobby did not move away from his natal territory, there was little overlap in the areas he and his mother roosted in. On several occasions during September Dobby was at the feeding station together with Wendy (observations were made from a hide, using night vision equipment; the birds' identities were confirmed by radiotelemetry). Dobby was being fed by Wendy, and taking food from the feeding station. Towards the end of September although Wendy still fed Dobby occasionally, she was often aggressive towards him.

John-Girl

Summary
John-Girl was caught and radiotagged on 28 November 1990. She spent four nights 21 January) close to the active Booming Sites 7, 8 and 9. On the night of 19 January she copulated at Site 7, presumably with Pegasus, who was caught at this site later in the season. John-Girl laid two fertile eggs. The first egg was laid on, or before, 28 January. On 20 February we removed one egg to Auckland Zoo. This egg hatched on 27 February, but the chick died when it was four days old, on 3 March, as a result of infections. The egg left in the nest hatched successfully on 1 or 2 March. The chick (subsequently named Stumpy) developed normally and left the nest between 9 and 15 May, 69 to 75 days after hatching. Before Stumpy left the nest he was banded and radiotagged. Stumpy remained in the John-Girl's home range until shortly after she died in mid-September 1991. He then

shifted 1 km to the north and we lost contact with him soon after, probably as a consequence of his radio-transmitter failing. The cause of John-Girl's death could not be determined as her carcass was in an advanced state of decomposition when found on 30 September.

Weight
Mean weight prior to supplementary feeding = 1.23 kg (n=16, sd=0.110)
Weights recorded since supplementary feeding began:

08 Oct 89	1.50 kg
03 May 90	1.37 kg
28 Nov 90	1.58 kg
04 Aug 91	1.38 kg
06 Aug 91	1.47 kg

Previous breeding history
John-Girl probably didn't attempt to breed during the 1989-90 breeding season. She was captured and examined on 3 April 1990, at which time she didn't have a nest or brood patch.

Supplementary feeding
John-Girl was taking supplementary food consistently from early 1990 onwards. Between 25 December 1990 and 16 January 1991 she fed at one of the feeding stations nightly. She visited booming sites for copulation during the period 17-22 January, and when she returned she fed nightly for five nights, 24-28 January, before settling on a nest. During the first three weeks of incubation she fed irregularly (on 14 nights out of 24 during the period 29 January - 21 February) but during the final week of incubation she began feeding nightly and continued to do so. The quantities of foods taken increased dramatically during brooding and again after fledging. From mid-March onwards Girl also took water at the feeding stations, presumably to moisten food for regurgitation to her chick. See Powlesland and Lloyd (1992) for further details.

Pre-nesting movements
Until 17 January John-Girl routinely roosted in the vicinity of her feeding stations, then for the four days 18 -21 January she roosted close to active booming sites: 18 January 200 m west of Booming Site 9, 19 January 200 m south-west of Site 7, 20 January 50 m south of Site 7, 21 January 20 m west of Site 9. From 22 January onwards she roosted at her nest site.

Copulation
John-Girl spent four nights (17-21 January) close to the active Booming Sites 7, 8 and 9. On the night of 19 January she copulated at Site 7, presumably with Pegasus, who was caught at this site on 25 February in a cage trap.

Nest log

Incubation (Laying date: 28-30 January 1991)

25 Jan, 16.00: We approached to within 2 m of the nest, John-Girl could be seen in the nest, but was not disturbed.

28 Jan, 16.05: The nest was inspected, John-Girl didn't respond; we lifted her to one side to reveal one egg, but there could have been more.

15 Feb, 20.00-1.00: John-Girl's movements were monitored remotely but because she remained in or near the nest we didn't inspect it.

17 Feb, 20.00-22.00: John-Girl's movements were monitored remotely until she left the nest. We then inspected the nest contents, there were two eggs which we numbered and candled. We replaced the eggs together with a temperature sensitive artificial egg.

20 February, 10.40: Both eggs were removed and candled. Egg #2 was placed in a portable incubator at 95 F and taken to Auckland Zoo by helicopter. Throughout the visit John-Girl continued incubating the artificial egg.

Brooding

(Hatching date: c. 2 March; Fledging date: c.11 May, aged 70 days; Chick name: Stumpy) During the nestling period all nest visits were made at night while John-Girl was absent from the nest. From Day 1 on 3 March to Day 45 on 16 April the nest was visited by us every three days. Subsequently the interval between visits increased to between five and ten days. During visits the chick was weighed, measured, and photographed; developmental details were also noted (see Section 3.4.2 for details).

Key visits were:

03 Mar, Day 1: The chick was first seen, probably 1 day old. No egg shell fragments were found in the nest.

21 Apr, Day 50: The chick was banded KA 0133.

01 May, Day 60: The chick was radiotagged.

09 May, Day 68: This is the last time the chick was seen in the nest; he sat close to the entrance.

15 May, Day 74: The fledgling was 5 m from the nest, perched on a stump above the nest. The nest chamber looked as if it had not been used for several days.

Post-fledging

John-Girl and her fledgling (Stumpy) roosted together within a few metres of the nest for the first 16 days after fledging. During June they generally roosted separately, up to 100 m apart, away-from the nest, and close to a feeding station. Throughout July, August and early September the areas John-Girl and Stumpy roosted in were adjacent with some overlap. Generally Stumpy was within 200 m of the nest site and well within John-Girl's traditional home range. Although he may have fed at the two supplementary feeding stations in the female's home range there is no proof of this. John-Girl died in mid-September and soon afterwards Stumpy left the natal home-range and shifted 1 km to the north. We lost contact with him soon after, probably as a consequence of his radio-transmitter failing.

Artificial rearing

On 20 February at 10.40 one egg (#2) was removed from the nest, candled, placed in a incubator at 95 F, and transferred to Auckland Zoo by helicopter. Details of its subsequent fate were provided by Dr. R. Jacob-Hoff, Senior Curator at the Auckland Zoo.

The egg hatched successfully on 27 February in an incubator at the zoo. The chick was held at standard brooding temperatures and fed with a commercial parrot formula using a syringe. The chick developed well, appearing vigorous and healthy. During the four days following hatching it increased its weight by 39%. On 3 March, at age 4 days, the chick died after an illness of 3-4 hours characterised by signs of digestive disorder and respiratory distress. Autopsy results indicate that the chick suffered a digestive disorder caused by a *Klebsiella* infection which led to regurgitation; food particles were inhaled and these induced a severe pneumonia, physiological shock and death.

Bella-Rose

<u>Summary</u>
Bella-Rose was caught and radiotagged on the 19 October 1990. Although she moved widely during late January and early February 1991 she remained on the lower half of the island, below 400 m a.s.l and we do not believe that she visited any active booming sites. Subsequent regular monitoring did not provide any evidence of her having a nest.

<u>Weight</u>
Mean weights prior to supplementary feeding = 1.42 kg (n=3 sd=0.153)
Weights recorded since supplementary feeding began:

17 Sep 89	1.68 kg
12 Oct 89	1.75 kg
19 Oct 90	2.09 kg
30 Sep 91	1.81 kg

<u>Weight</u>
Bella-rose probably didn't attempt to breed during the 1989-90 breeding season. She was captured on 19 February 1990 at which time she did not have a nest or brood patch.

<u>Supplementary feeding</u>
Bella-Rose fed almost nightly except for the 62-day period 16 December 1990 -18 February 1991 at the beginning of the breeding season. During this period she fed irregularly during the period 27 December -10 January; and on the nights 20, 26, 27, 28 January & 6,11,12 February.

<u>Pre-nesting movements</u>
Up until 22 December 1990 Bella-Rose routinely roosted close to her feeding station. From then until 21 February 1991 she moved widely, only returning to her feeding station for a few days at a time. Between 13 and 19 January 1991 she roosted c. 1.5 to the east of her feeding station in the mid-altitude region on Track 17 and 19. She returned to her feeding station briefly and then moved c. 1 km north-west to Tracks 2 and 3 where she roosted from 21-25 January. She returned briefly to her feeding station before again moving northwest, c. 1.5 km across to Track 3 and then Track 5 between 1-5 February 1991. After another brief visit to the feeding station area she moved about 500 m to the east and she roosted there from 8-10 February. From 21 February onwards she resumed roosting close to her feeding station.

<u>Copulation</u>
Despite her extensive wandering early on in the booming season when copulations

usually occur, Bella-Rose did not appear to climb above about 400 m a.s.l and probably did not visit an active booming site even though she was almost certainly able to hear booming. There was no sign of copulations at the booming sites nearest to her.

Nesting
On *25* January we approached Bella-Rose closely during the day to see whether she was nesting. She was roosting close to her feeding station in the open and moved away when approached. There was no indication of a nest at this time and throughout the rest of the breeding season her daytime roosts shifted frequently indicating that she was not on a nest.

3.2.3 Nest locations and descriptions
The heights above sea level are in imperial units as used on the map in Hamilton (1961).

Maggie

The nest (150 ft a.s.l.) was near the bottom of a gully, 10 m above a stream which retained water during the nest period. The surrounding forest had a high, closed canopy of pohutakawa (*Metrosideros excelsa*), puriri (*Vitex lucens*), and taraire (*Beilshmiedia taraire*); and a relatively open understory.

The nest was in a 4 m long cavity, 180 mm high and 200 mm wide, in the horizontal trunk of a pohutakawa. The entrance faced uphill and, although it was 570 mm above ground level, there were gently sloping roots leading up to it. The nest was 450 mm in from the entrance and was a bowl shaped depression lined with bark, dried leaves and wood fragments.

Heather

The nest (680 ft a.s.l) was located 30 m from one of our tracks on an exposed cool ridge facing south east. The surrounding forest had a scattered, open canopy of kauri (*Agathis australis*) and kanuka (*Kunzea ericoides*); and a scattered, low undergrowth of *Gahnia* sp., *Blechnum* sp., *Astelia trinerva* and ponga (*Cyathea dealbata*).

The nest was on the ground, under the leaves of a clump of *Gahnia* sp. A 300 mm high bank ran along the back edge of the nest bowl. The entrance faced downhill to the SSE. Although the *Gahnia* leaves concealed the nest well, they did not provide an effective protection from wind and rain.

John-Girl

The nest (1100 ft a.s.l.) was located 10 m from a track on a broad ridge with a southerly aspect. The surrounding forest was mature, with a high closed canopy of tawaroa (*Beilschmiedia tawaroa*) and taraire (*B. taraire*). Undergrowth was varied and generally dense, including thickets of kiekie (*Freycinetia baueriana*).

The nest was in a large chamber in the side of a 3 m hillock formed by the root of a dead tree. The entrance was on the downhill side of the hillock and faced south-west. The entrance aperture was 300 x 300 mm, 120 mm above floor of nest cavity. The nest cavity extended back 1160 mm from entrance and was 840 mm across at the widest point; a 500 x 500 mm annex to the left of the entrance gave the nest cavity a total length of c. 1600 mm. The maximum height of the cavity was 530 mm. The floor was flat and consisted of dry humus or peat. The ceiling and walls were rotted wood. The nest was very dry and sheltered. It remained dry after very heavy rain.

Wendy

The nest (1300 ft a.s.l.) was located on a sunny west facing slope deep in a large valley. The surrounding forest was mature, with a high and complete canopy of hard beech (*Nothofagus truncata*), tawaroa (*Beilschmeidia tawaroa*), rata (*Metrosideros robusta*). The undergrowth was varied and dense with supplejack (*Ripogonum scandens*), kiekie (*Freycinetia baueriana*), mapou (*Myrsine australis*), kohurangi (*Brachyglottis kirkii*), mingimingi (*Cyathodes fasciculata*), *Astelia* sp.

The nest was in a large chamber among the buttressed roots of a large (d.b.h. 2.0 m) hard beech (*Nothofagus truncata*). There were two separate entrances, each c. 200 mm diameter, on opposite sides of the tree facing west and north. There was more than 3 m between the two entrances and there seemed to be a massive chamber in the centre more than 1 m in from both entrances. The eggs were incubated within 800 mm of the western entrance but later Wendy and the nestlings moved deep into the main chamber. The floor was flat and consisted of dry humus or peat. The ceiling and walls were rotted wood. The nest was well concealed and very sheltered but during a period of heavy rain some of the nest floor became wet.

3.2.4 Nest attendance

Incubation

Remote radio-monitoring of three of the incubating females (Maggie, Heather, and John-Girl) provided some information on nest attendance during incubation. Remote monitoring comprised both occasional instantaneous monitoring during the day, and prolonged monitoring during the first 4 -5 hours of darkness on a number of nights. The information is not comprehensive but provides some indication of the pattern of attendance:

> **Daytime**: Females were on the nest on all occasions that nests with eggs were monitored during daylight.
>
> **Nighttime**: At night the females were active for 5-10 minutes shortly after dark, usually c. 30 minutes after official sunset. During this activity bout the females remain either in or close to the nest. There were similar short bouts of activity at approximately hourly intervals throughout the rest of the night. Longer periods off the nest to feed (at feeding stations) did not happen nightly. Early in incubation such feeding periods lasted only c. 30 minutes but towards the end of incubation a female was recorded as being away from the nest for 70 minutes.

Brooding

Our daytime visits to Wendy's nest throughout most of the brooding period indicate that she spent most daylight hours in the nest. Our regular night-time visits to John-Girl's nest provided reliable information on night-time nest attendance during brooding (Table 6).

Table 6. Nest attendance by John-Girl during chick brooding.

Chick age is in days since hatching; Day 1 = 3 March 1991.
Departure time is minutes after official sunset for Auckland.

Chick age	Departure time	Minutes away
4	33	63
7	16	50
10	34	140
13	36	50
16	27	58
19	24	86
22	36	85
25	28	77
28	25	139
31	15	(>81)
34	67	(>89)
37	33	123
40	29	154
42	22	(>69)
45	52	(>98)
50	17	(>45)
60	128	52
68	42	80

3.2.5 Incubation temperatures

Table 7. Incubation temperatures (C) measured at two nests using a temperature sensitive artificial egg.

Date	Time	Mean	N	Min	Max	Range
Maggie						
27 Jan	10:50	36.7	1	-	-	-
	18:20	36.7	1	-	-	-
29 Jan	12:00	36.7	1	-	-	-
John Girl						
18 Feb	07:15	36.2	1	-	-	-
19 Feb	17:10-18:38	36.77	3	36.7	36.9	0.2
20 Feb	10:30-10:40	36.98	2	36.75	37.2	0.45
--- 10:40-10:50 Female disturbed and one egg removed from the nest ---						
	11:05-11:15	36.57	3	36.4	36.7	0.3
	12:00-12:45	37.27	5	36.3	37.9	0.6
	15:20-16:00	37.04	5	36.8	37.3	0.5
21 Feb	15:25-15:45	37.40	3	37.4	37.4	0.0
22 Feb	15:55-16:15	36.48	3	36.2	36.75	0.55

The normal daytime temperature of eggs being incubated

The normal daytime temperature of eggs being incubated was determined from the series of temperature obtained from two nests shown in Table 7. Data obtained during periods following disturbance was excluded (i.e. 20 Feb 11.15 - 21 Feb 15.45). The average temperature of eggs during normal daytime incubation was 36.65 C, varying from 36.2 to 37.2 °C.

The effect of nest disturbance on egg temperatures

Results of monitoring egg temperature during and following our visit to the nest show that disturbance at the nest was followed by an initial minor cooling of about half a degree (presumably a result of the eggs being exposed) followed by an increase to 37.9 C one hour after disturbance, more than one degree above normal temperature (probably a consequence of the female's increased metabolism due to agitation). Higher temperatures were also observed on the day following disturbance but normal, lower, temperatures were observed two days after the disturbance.

3.2.6 Egg data

Morphometric data

Table 8 is morphometric data on eggs handled during the 1990-91 breeding season: weight (g), length (mm), breadth, i.e. the greatest diameter (mm) and the volume and density of each egg computed using the formulae (Jordan and Mattachione 1989):

$$\text{Volume} = \text{Length} \times (\text{Breadth})^2 \times 0.51.$$

$$\text{Density} = \text{Weight}/\text{Volume}$$

Egg density provides a good indication of viability (Jordan and Mattachione 1989).

Table 8. Kakapo egg data recorded during the 1990-91 breeding season.

Female	Date	Age (days)	Egg No.	Weight (g)	Length (mm)	Breadth (mm)	Volume (cc)	Density (g/cc)
Maggie	27 Jan	5	1	38.0	48.1	38.5	36.36	1.045
	5 Feb	14	1	36.545	47.7	38.6	36.25	1.008
Heather	5 Feb	9-15	1	36.557	49.5	37.9	36.26	1.008
J-G	20 Feb	21-23	1	36.75	47.8	38.8	36.70	1.0014
			2	37.5	47.0	39.3	37.02	1.0129
Wendy	17 Mar	45	3	.	51.1	38.4	38.43	.

Information from candling

Maggie's egg
One egg laid c. 21 January.
The egg was candled on 27 January. There was a poorly defined central mass 20 mm across with no venation or embryo apparent but the size of the air cell indicated that the egg had been incubated for 5 days. It was concluded that the egg was infertile or had died during early development. It was transferred to Auckland Zoo on 29 January in an incubator at 95 F. Examination by experts at Auckland Zoo and Animal Health Laboratories confirmed that there was no evidence of an embryo.

Heather's eggs
Two eggs laid c. 21-27 January.
The two eggs were transferred to Auckland Zoo on 3 February, 7-13 days after laying. They were candled when first removed:
Egg #1-There was a 7 mm long embryo surrounded by a blood ring. (In domestic poultry a 7 mm embryo would be approximately 5 days old.) The egg was fertile but had died 24 hours before candling.
Egg #2 -There was a poorly defined central mass with no venation or embryo apparent. The egg was infertile or died during early development.

John-Girl's eggs
Two eggs laid c. 28-30 January.

17 Feb, 18-20 days after laying.
The eggs were both well vasculated with medium to large air spaces. A small amount of albumin was visible at the small end of Egg but none was apparent in Egg #2. Egg appears to be 6-8 days before hatching, Egg looked 2-3 days more advanced.

20 Feb, 21-23 days after laying.
Egg had not developed noticeably since 17 February. Egg #2 had a very dark embryo occupying the entire egg except for a small well defined air cell. There was no sign of the egg tooth breaking through the air cell membrane. Egg was removed to Auckland Zoo on 20 Feb and hatched on 27 February.

Wendy's eggs
Three eggs laid c. 19 January.
One inviable egg was retrieved from nest on 17 March after c. 45 days incubation. Two other eggs in the nest hatched around 1 March.

3.2.7 Period of rapid yolk deposition

J. Cockrem of Massey University determined the period of rapid yolk deposition for the infertile egg taken from Heather's nest (Cockrem, in prep). There were 7 growth rings, indicating that the likely period of rapid yolk deposition was 8-10 days, which is not unusually long for an egg of this size.

3.2.8 Chick Development

Wendy's nest - Surviving chick: Dobby - Estimated hatching date 21 February.
John Girl's nest - Chick name: Stumpy - Estimated hatching date 2 March.

Most of the observations on chick development were made at John-Girl's nest because access to Wendy's nest was difficult and prevented regular and detailed observations. The few close inspections of Wendy's chicks confirmed the general pattern of development recorded at John-Girl's nest but Wendy's surviving chick seemed to develop more slowly than John-Girl's. Towards the end of the nestling period the plumage development of Wendy's chick was 10 days behind that of John-Girl's chick.

Weight
Figure 2 is the weight, in grams, of the chicks plotted against their estimated age, in days after hatching. The data are provided in Appendix C.

Tarsus Length
Tarsus length, culmen width and culmen length were all recorded occasionally and can be found in Table 12.

Eyes
The eyes began to open about 13 days after hatching, but were not fully open until 18 days.

Feet
Nineteen days after hatching the outside toe was noted curling around to the back. By 22 days zygodactyl feet were fully developed.

Vocalisation
On the first day after hatching the chick made a low churring noise when picked up. Subsequently it vocalised quietly throughout handling until about 30 days when it began squealing or grunting loudly. It was not until 50 days after hatching that the undisturbed chick was heard vocalising in the nest.

Mobility
During the first few days after hatching the chicks were weak and uncoordinated, unable to sit up. Twenty days after hatching they were they able to sit up on their haunches with their head up but they were still docile when handled. By 30 days the chicks were quite

active and difficult to handle. At 40-50 days after hatching the chicks sat quite upright and moved around easily in the nest chamber.

Fledging and post-fledging

As early as 55 days after hatching the chicks were sitting outside the main nest chamber, close to the nest entrance. From 65-75 days the chicks sat in or just outside the nest entrance. For a further c. 15 days after leaving the nest the chicks roosted with the female, ten to twenty metres from the nest. Subsequently they roosted up to 100 m from both the nest and the female but close to feeding stations.

Plumage

Plumage descriptions for 5-day age periods

Age (days)	Plumage description
0-5	The chick was covered with thick white down.
6-10	-
11-15	The chick was still covered by thick white down, but feather tracts were apparent under the skin.
16-20	The sheathed feathers of both body contour plumage and secondaries erupted through the skin. There was a small brown tassel at the tip of each sheath.
21-25	At the start of this period the brown tips of the sheathed contour feathers and grey down gave an overall brown/grey appearance to the plumage though there was green feathering on the thighs where the vanes of contour feathers were beginning to unfurl. By 25 days the green feathering was extensive on the thighs, breast, wing coverts, and secondaries. The primary feather sheaths and then the tail feather sheaths erupted through the skin.
26-30	The crown and rump were covered in thick dark grey down without any contour feathers. Green feathering was thick on the thighs but still sparse on the breast. The vanes of contour feathers on the thighs, wing coverts and secondaries were 10-30 mm unfurled. Green feathering of the forehead and nape began. Primary and tail feather vanes were still not unfurled.
31-35	The rump was dark grey down, and there was now a hint of green feathering on the crown and nape as a few feather vanes unfurled 2-4 mm. Green feathering on the breast was sparse with the unfurled vanes 10-15 mm long. The length of unfurled vane on the secondaries increased from about 10 mm to 30 mm. The primary and tail feathers started to unfurl.
36-40	The rump was still dark grey down. Feather vanes unfurling on the thighs, crown, belly, secondaries, primaries and tail.

41-45	Rump still entirely dark grey down; green feathers unfurling everywhere else. The crown and chest were almost completely feathered.
46-50	Rump still entirely dark grey down; green feathers unfurling everywhere else. Crown, face, chest, and wing coverts almost completely feathered with just a few wisps of down poking out. The primary and secondary and tail feathers were still unfurling. The tip 10-20 mm of the inner web of primaries was now formed: - dark with bold yellow reticulations 1-1.5 mm wide.
51-55	-
56-60	The contour plumage was almost complete except for small amounts of down on the lower rump, flanks, and underside of wings. Primary, secondary, and tail feathers were half unfurled. The green plumage was noticeably paler than adult plumage.
61-65	-
66-70	Down was still apparent on the flanks and under the wings, otherwise the green contour plumage was complete. Primary, secondary, and tail feathers were approximately two-thirds unfurled.
71-75	There were small patches of down on the flanks and under the wings, only visible when the wings were raised, otherwise the contour plumage was completely feathered. The longest feather in the tail was 130 mm long with pieces of sheath on the rachis. The primary feathers were approximately three-quarters unfurled.
100-110	The contour plumage was complete though the pattern on the back seemed finer than in adults. The primary feathers were completely unfurled, with only a few flakes of sheath at the base of rachii. Stumpy's tail was completely grown but only 170 mm long, whereas Dobby's tail at 185 mm appeared to be still growing. The trailing edges at the tip of the primaries were dark with bold yellow reticulations. There were some faint watermarks or dappling present on Stumpy but not on Dobby. All primary and secondary feathers were pointed.

Growth of ninth primary

Figure 3 is a plot of the length (mm) of the sheathed region and the total length (mm) of the ninth primary (counted from the inside), of the right wing, against age (days since hatching) for the two chicks.

Figure 2: Weight, in grams, of the chicks plotted against their estimated age, in days after hatching. The data are provided in Appendix C

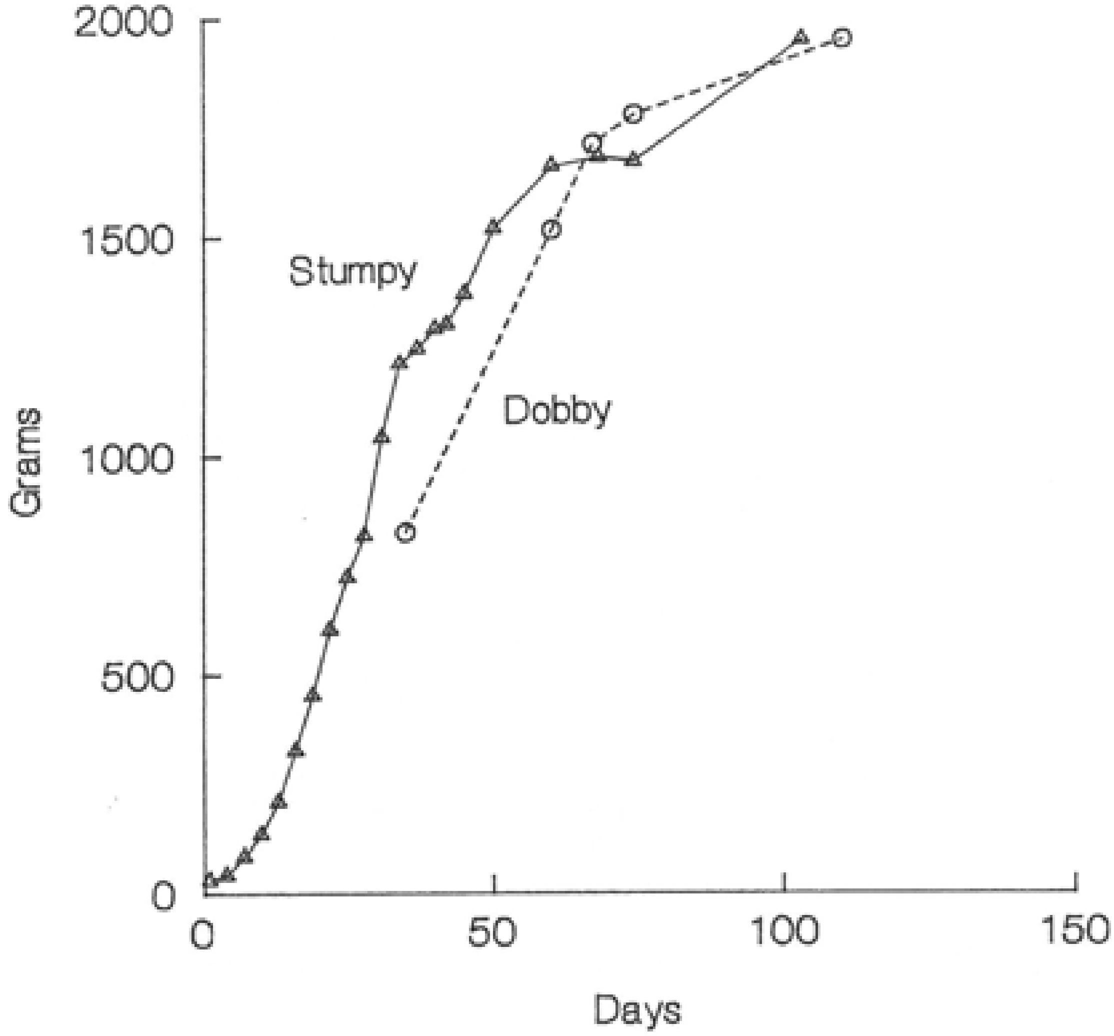
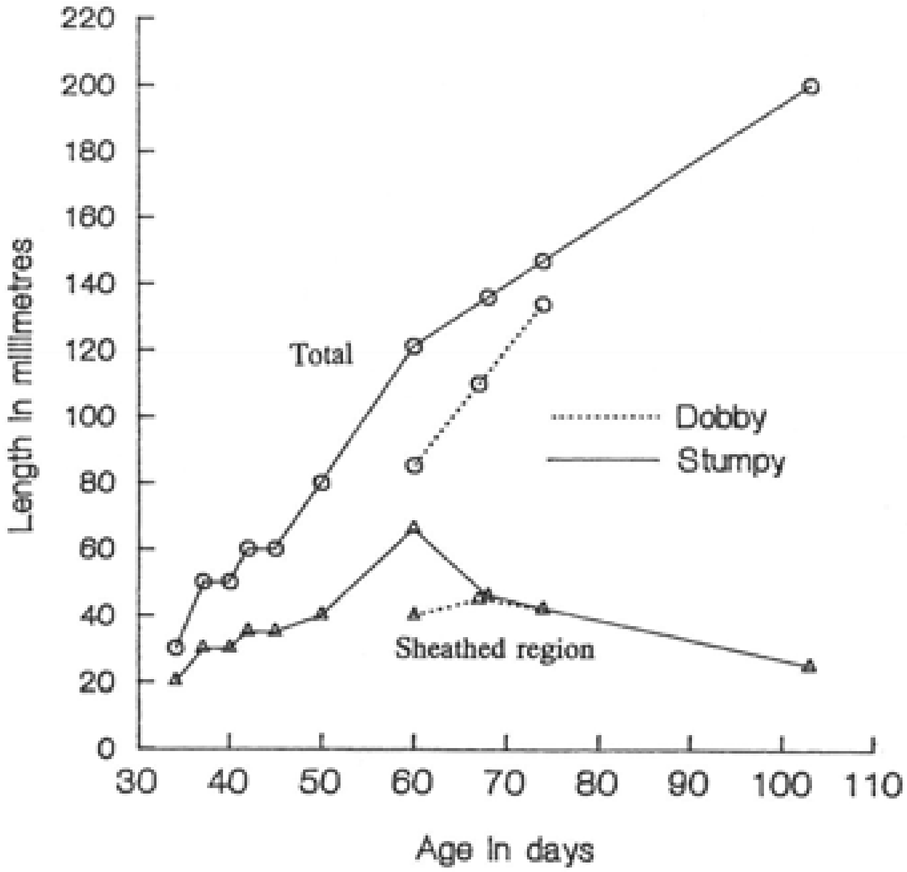


Figure 3: The length (mm) of the sheathed region and the total length (mm) of the ninth primary (counted from the inside), of the right wing, against age (days since hatching) for the two chicks.



3.2.9 Sexing chicks

Feather pattern

Powlesland (1989) describes a method to determine the gender of adult kakapo from the pattern at the tip of the inner or trailing vane of the outer primaries. At 50-60 days after hatching the distal 20 mm of the inner vane of the outer primaries were sufficiently well formed on both chicks for us to attempt to use this method to determine their gender. At this time the trailing vanes were dark brown or black with bold yellow reticulations 1-1.5 mm wide. The patterns on the trailing vanes were unchanged 30 to 40 days after fledging. The patterns did not correspond to either of the patterns described by Powlesland. (A very feint dappling was discernible on the vane of Stumpy 40 days after fledging but it was not felt to be sufficiently well developed to determine the bird's gender.) Thus it seems that kakapo's juvenile plumage can not be used reliably to determine gender.

The gender of adult kakapo can also be determined using tarsus length and culmen width. There was almost no overlap in the ranges of values of these two measurements from samples of male and female kakapo on Stewart Island (Table 11). Values of tarsus length, and culmen width measured at irregular intervals from 42 days after hatching are shown for both chicks in Table 12. All values for both measurements for Stumpy are outside the ranges of values for females and within the ranges of values for males. For Dobby the first value for tarsus length, measured 60 days after hatching, was within the range of values for females, all subsequent values of both measurements were outside the ranges for females and within the ranges for males. We concluded that both chicks were male.

Table 11. Sample statistics for tarsus length and culmen width data from known gender kakapo.

	Mean	N	Min	Max	SD
Tarsus Length					
Female	53.34	9	50.1	55.5	1.6448
Male	58.90	12	55.4	62.1	2.2583
Juv. Male	58.63	3	56.9	59.9	1.5567
Culmen Width					
Female	20.51	7	20.3	20.8	0.1773
Male	23.15	13	21.2	25.7	1.1997
Juv. Male	23.53	3	23.0	23.9	0.4726

Table 12. Tarsus length and culmen width, Stumpy and Dobby.

	Chick Age (days)	Tarsus Length (mm)	Culmen Width (mm)
Stumpy			
	42	56.1	.
	60	56.8	23.8
	68	56.8	.
	103	57.5	23.05
	214	57.3	22.8
Dobby			
	60	54.1	.
	67	56.6	.
	74	56.6	21.6
	110	56.65	21.8
	233	56.0	22.4

3.2.10 Potential nest problems

Kiore
Rodent control was undertaken around both John Girl's and Wendy's nests. Non-toxic pre-bait was placed in silos around John-Girl's nest on 10 February, and Wendy's nest on 6 February. Ten days later the pre-bait was replaced by toxic bait which was replenished regularly until the silos were removed (3 April, John-Girl's nest; 20 April Wendy's nest), just before the kakapo chicks left the nests. No kiore activity was noted around, or in, any nests.

Mites
Nest material from each of the nests was regularly inspected closely for mites. No mites were found.

Bacterial infections
On the 18 March, sixteen days after hatching, a swab and faecal sample were obtained from John-Girl's chick and sent to Auckland Zoo for a bacterial check. No pathogens were identified.

Petrels
When Wendy's nest was first inspected on 26 January a dead Cook's petrel (*Petrodroma cookii*) could be seen at the back of the nest chamber. When we removed it three days later it was maggot-ridden. A fresh dead petrel was also found outside the nest on 25 February. Both petrels may have been killed by Wendy.

Soiled feathers
During the first 4 weeks after hatching, down on John-Girl's chick repeatedly became encrusted with food material regurgitated by the mother.

On the first day after hatching, down feathers under the wing and at base of bill were matted with nest material. At four days it was noted that food material encrusted one eye and feathers at the base of the bill. This material was washed off by us with warm water during our next nest visit, three days later, but fresh material again encrusted the facial feathers at ten days. The feathers remained encrusted until 25 days when they were again cleaned by us. Feather encrustation was not subsequently observed.

Malformed feather
When Dobby was handled on 11 June, 40 days after he left the nest, it was noted that the outer primary of the left wing was bent outwards.

3.3 Supplementary feeding

Details of the supplementary feeding programme can be found in Powlesland and Lloyd (1992). All five females had been feeding regularly at supplementary feeding stations for at least 6 months prior to January 1991. Several of the males were also taking food regularly prior to the booming season at feeding stations placed either near booming sites or within female's home ranges. Information on supplementary feeding by individual males is of poor quality as the males were not radio-tagged.

3.4 Rat index trapping

Table 13. Results from rat index trapping, Little Barrier Island, 1990-91.

Table 13. Results from rat index trapping, Little Barrier Island, 1990-91.

Date	Total captures	Juv (<45 g)	Capt/100 nights
Nov 1990	12	0	4.6
Jan 1991	11	1	4.3
Mar 1991	66	20	29.5
May 1991	82	11	37.6

4 DISCUSSION

4.1 A summary of breeding activity on Little Barrier Island 1982-1991

Table 14 is a summary of breeding activity on Little Barrier Island since kakapo were released on the island.

Table 14. Breeding activity on Little Barrier Island 1982-1991.

Summer	Booming Heard	Males Active	Start of Activity	End of Activity	Evidence of Copulation	Nests Found
82-83	No	0	.	.	No	No
83-84	Yes	3-5	?	Mid-Apr	No	No
84-85	Yes	c. 8	?	Mid-Apr	No	No
85-86	Yes	>7	Early Jan	Mid-Apr	No	No
86-87	No	3-5	Late Dec	Late Jan	No	No
87-88	Yes	7-8	Early Jan	Mid Mar	No	No
88-89	Yes	9	Early Jan	Mid Mar	No	No
	-------- Supplementary feeding begun Sept. 1989 --------					
89-90	Yes	11-13	Late Dec	Mid Apr	Yes	Yes
90-91	Yes	10	Early Oct	Early Apr	Yes	Yes

Since supplementary feeding was begun on Little Barrier Island in September 1989:

- The 1989-90 booming season was the most intensive since kakapo were transferred to Little Barrier Island.
- The 1990-91 booming season began earlier than has ever been previously recorded for any kakapo population.
- Nesting has occurred in both summers, whereas there is no evidence of nesting during the seven summers prior to supplementary feeding.
- Two of the females attempted to nest in consecutive years. This has not previously been recorded for kakapo.

It therefore seems reasonable to conclude that on Little Barrier Island supplementary feeding has promoted breeding by both male and female kakapo.

4.2 A comparison of breeding on Little Barrier Island and Stewart Island

<u>Booming</u>

The 1990-91 booming season on Little Barrier Island was more extended than any recorded on Stewart Island. Several males were booming by mid-October and booming continued until early April, whereas during the most intensive booming seasons monitored on Stewart Island (1980-81 and 1984-85) booming only began in mid-December and ended in April (Powlesland *et al.* in press).

Clutch size
Table 15 shows the sizes of clutches on Stewart Island (Powlesland *et al.* in press) and Little Barrier Island.

Table 15. Clutch sizes on Stewart Island and Little Barrier Island.

Island	Year	Clutch Sizes
Stewart Is.	1981	1 or more, & 3 or more
	1985	2,3 & 4
Little Barrier Is.	1990	1 & 1
	1991	1,2,2 & 3

Clutch sizes on Little Barrier Island in 1990 were smaller than those recorded on Stewart Island whereas clutch sizes on Little Barrier Island in 1991 were similar to those recorded on Stewart Island.

Chick weights
The two chicks on Little Barrier Island both weighed approximately 1.7 kg at fledging. Succesful fledging was only observed on Stewart Island during 1981. In that year a male weighing 1.5 kg fledged from one nest and a male weighing 2.2kg and a female weighing 1.7 kg fledged from a second nest. Thus during the 1981 breeding season on Stewart Island the diet of one of the two females whose nests were monitored was probably superior to the supplemented diet of the two females with fledglings on Little Barrier Island in 1991.

Nest attendance
A comparison of data on nest attendance for the first few days of brooding presented here and in Powlesland et al. (in press) indicates that the female kakapo monitored on Little Barrier Island left the nest earlier but stayed away for shorter periods (33 minutes after sunset and 63 minutes away) than the female on Stewart Island during 1985 (60 minutes after sunset and 165 minutes away). The long periods spent away from the nest on Stewart Island were probably a consequence of the shortage of natural foods on Stewart Island in 1985.

4.3 Kakapo productivity

Table 16. The results of all known nesting attempts by kakapo between 1980 and 1991

		Females Monitored	Nests	Successful Nests	Eggs Laid	Infertile Eggs	Chicks Hatched	Fledglings
Stewart Is.	1981	7*	2	2	≥4	.	4	3
	1985	4	4	0**	≥11	3	4	1**
L.B.Is.	1990	4	2	0	2	1	1	0
	1991	5	4	2	8	3	4	2***
	Total	20	12	4	≥25	7	13	6

* - The females were checked mid way through nest period and may have lost nests at an early stage.

** - The fledgling only survived as a result of intervention by us, it was fed by us and then taken into captivity.

*** - One egg was removed to the zoo where the chick died; it might have fledged successfully if it had been left in the nest as its nest mate survived.

Nesting has occurred in only four years during the eleven years, 1980-91, that kakapo populations have been monitored (Table 16). In these four years the monitored females nested a total of 12 times and produced at least 25 eggs. Seven eggs were infertile, 13 hatched, 6 young fledged, but only 5 to the sub-adult stage. Two other young were probably produced on Stewart Island in 1981 by females not being monitored. The frequency of nesting attempts, and the success rate of nests in the wild is very low. This is true even under what appear to be ideal circumstances on Little Barrier Island, i.e. ad libitum supplementary food, the absence of significant predators, and relatively mild climate. Low reproductive rates are probably normal for large parrots in the wild. For instance, the world's second largest parrot species, the Hyacinth macaw (*Anodorhynchus hyacinthinus*) is reported to nest about once every three years and produce no more than one chick from a nest (Munn *et al.* 1991).

The total number of females has declined from c. 30 in 1980 to c. 15 in 1991. During this time seven young, including only two females, have been recruited to the adult population. The kakapo population is rapidly approaching what Gilpin and Soule (1986) described as an "extinction vortex" from which it can only be rescued by prompt intervention. The results of the last two years' work on Little Barrier indicate that although intensive management of population in the wild (i.e. supplementary feeding, nest protection and rodent eradication) will improve the species productivity, the improvement may not be sufficient to reverse the species decline. Many large species of parrots have been bred successfully in captivity, usually productivity being enhanced (e.g. a pair of hyacinth macaws produce a maximum of 1 young every three years in the wild whereas in captivity they can produce up to 8 young in one year, Munn *et al.* 1991). It is essential that there is an increased emphasis on in the Kakapo Recovery Programme. Aviculture should include breeding from captive stock, and artificial incubation and rearing of progeny from both wild and captive birds.

4.4 Male breeding success

Table 16. Copulation details 1989-90 and 1990-91

	Night	Female	Site No.	Prob. Male
1989-90	12 Jan 90	.	24	Bill
	26 Jan 90	Heather?	7	Barnard or Pegasus?
1990-91	2 Jan 91	Wendy?	24	Bill
	12-13 Jan 91	Heather	24	Bill
	19 Jan 91	J-Girl	7	Pegasus
	22 Jan 91	.	49	Pegasus

There were at least 10 males booming during both the 1989-90 and 1990-91 breeding seasons, but the six recorded copulations can be reasonably attributed to only two males: Bill and Pegasus (Although Barnard was found near Site 7 in March 1990, at this time of the year males are inclined to leave their usual systems. He was found at Site 12 in February 1990 and was probably booming there during January when copulations occurred.) Thus two males, or their booming sites, are being selected by the females. Although the two offspring from this breeding season were fathered by separate males, male mating success is heavily skewed.

In small populations loss of genetic diversity can be reduced by ensuring that all males contribute equally to future generations (Frankel & Soule 1981, Shaffer 1987). This is especially important for kakapo at present because the high proportion of males in the population (c. 37 males and c. 17 females) means that most of the populations genetic variation resides in males. Therefore until the population has recovered to a moderate size (i.e.>50 breeding females) males that have already produced a large number of progeny and are over-represented in the succeeding generation should be removed from the breeding population. In order to manage the free-living population in this way it will be necessary to monitor paternity by either: using DNA fingerprinting techniques; or monitoring the identity of males and females at booming sites, and progeny in the nest.

Critics of a management regime of this type argue that the removal of successful breeding males may:

- reduce the overall productivity of the population.
- thwart the process of natural selection.
- lead to a population poorly adapted for its environment.

We do not agree with these assertions:

- Removal of males over-represented in the next generation is unlikely to reduce the overall productivity of the population because the species is polygynous and at present there is a large surplus of males in the population.

- Although long term studies (see Newton 1989 and Mills 1990) indicate that in natural populations breeding success is often heavily skewed, thus providing the mechanism for natural selection, in small relict population of previously widespread species changes in gene frequencies caused by natural selection are likely to be swamped by the random loss of genetic material which reduces genetic diversity in succeeding generations.

- If kakapo survive in the long term progeny from Little Barrier Island will be moved to a wide variety of other environments. Thus it is important to retain the species genetic diversity to facilitate survival in diverse environments.

Simberloff (1988) provides a comprehensive discussion of these issues.

5 CONCLUSIONS

- Supplementary feeding promoted breeding effort by both male and female kakapo.

- Females attempted to nest in consecutive years. Thus it is likely that the female's reproductive cycle is annual and irregular nesting is a consequence of poor nutrition.

- Females fitted with back-mounted radio-transmitters mated and nested successfully.

- This season's observations that feather clusters (as described in Section 2.1.4) at booming sites are evidence of copulation.

- Nest manipulation and intensive nest monitoring (including: handling eggs and chicks, and egg substitution) can be carried out without jeopardising the success of nests.

- Despite high numbers of kiore present throughout the latter half of the nest period none of the nest contents were preyed on by kiore. We can not be sure, but this may have been a result of the control programme carried out around the two nests with nestlings.

- Intensive management of wild populations may he insufficient to prevent extinction of kakapo and should be supplemented by an intensive avicultural programme.

- Male breeding success is likely to be highly skewed.

6 RECOMMENDATIONS

- Supplementary feeding should be continued on Little Barrier Island, refined, and extended to other wild populations.

- Intensive management of the wild population should be supplemented by an intensive avicultural programme which should include breeding from captive stock, and artificial incubation and hand-rearing of progeny from both wild and captive birds.

- Long term management of kakapo should include genetic management to achieve even spread of progeny from the males. Males that have a large number of progeny, and are over-represented in the succeeding generation, should be removed from the breeding population. In free-living populations this will require monitoring of paternity which may be achieved by either: using DNA fingerprinting techniques; or monitoring the identity of males and females at booming sites, and progeny in the nest.

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Appendix A: Capture details for 1990-91

All birds were in good condition when handled. The only bird in moult was Maggie; her wing and tail feathers were in the final stages of moult. Each of the females was fitted with a radio-transmitter when captured.

Males

Date	Bird	Weight (kg)	Booming Site	Booming Sac
19 Oct 90	Luke	2.27	9	No
19 Oct 90	Arab	3.20	8	Yes
19 Oct 90	Pegasus	3.14	7	Yes
20 Oct 90	Rob	3.32	?	Yes
25 Oct 90	Snark	3.12	21	Yes
25 Feb 91	Pegasus	2.35	7	Yes
6 Apr 91	Bill	1.80	24	No

Females

Date	Bird	Weight (kg)
24 Oct 90	Maggie	1.60
26 Nov 90	Heather	1.88
28 Nov 90	John-Girl	1.58
31 Mar 91	Wendy	1.47
19 Oct 90	Bella Rose	2.09

Appendix B: Active Booming Sites.

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.

* - System 1 is the system number used in 1989-90 season.
\# - System 2 is the system number used in 1990-91 season.

KEY:
. - NOT VISITED
0 - NO ACTIVITY SINCE LAST VISIT
1 - SOME RECENT ACTIVITY
2 - SOME DISTURBANCE SINCE LAST VISIT
3 - ACTIVE SINCE LAST VISIT
9 - DISTURBANCE, POSSIBLY PETREL ACTIVITY

System 1*	1	2	3	4	5	6			.			7			8		9	11		12			.	13		14	15			17		
System 2#	1	2	3	4	5	6			7			8			9		10	11		12			13	14		15	16			17		
Booming Site	10	09	08	49	07	12	41	50	14	42	43	19	20	21	23	24	25	35	45	26	27	40	44	33	36	31	16	17	18	47	48	
DATE																																DATE
01OCT90	.	0	.	.	.	.	.	.	.	.	.	0	0	3	.	.	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	01OCT90
02OCT90	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	02OCT90
03OCT90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	03OCT90
04OCT90	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	04OCT90
05OCT90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	05OCT90
06OCT90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	06OCT90
07OCT90	.	.	1	.	0	.	.	.	.	.	.	0	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	07OCT90
08OCT90	.	.	.	.	.	0	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	08OCT90
09OCT90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	09OCT90
10OCT90	.	0	0	0	0	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	10OCT90
11OCT90	0	0	0	0	0	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	11OCT90
12OCT90	0	0	0	0	2	.	.	.	.	.	.	0	0	3	.	0	0	.	0	0	3	0	0	.	.	0	.	.	.	0	0	12OCT90
13OCT90	0	0	3	0	3	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	13OCT90
14OCT90	0	0	3	0	3	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	14OCT90
15OCT90	0	0	3	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	15OCT90
16OCT90	0	0	0	.	3	0	0	.	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	2	3	0	0	0	16OCT90
17OCT90	0	0	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	17OCT90
18OCT90	0	0	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	18OCT90
19OCT90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	19OCT90
20OCT90	0	0	0	0	0	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	20OCT90
21OCT90	0	0	3	0	3	0	0	.	.	.	.	0	0	3	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21OCT90
22OCT90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	22OCT90
23OCT90	0	3	0	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	23OCT90
24OCT90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	0	24OCT90
25OCT90	0	0	3	0	3	0	0	.	0	0	0	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25OCT90
26OCT90	0	0	3	0	3	.	.	.	.	.	.	3	3	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	3	1	1	26OCT90
27OCT90	0	0	3	0	0	.	.	.	.	.	.	3	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	27OCT90
28OCT90	0	0	3	0	3	.	.	.	.	.	.	3	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	28OCT90
29OCT90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	0	0	0	0	0	0	0	0	0	0	0	.	.	.	0	0	29OCT90
30OCT90	0	0	3	0	2	0	0	.	.	.	.	9	2	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	3	0	0	30OCT90
31OCT90	.	2	3	0	0	.	.	.	.	.	.	0	2	3	0	.	.	.	.	.	.	.	.	.	.	.	0	3	3	0	0	31OCT90

Appendix B. (cont.) 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.

* - System 1 is the system number used in 1989-90 season.
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2 - SOME DISTURBANCE SINCE LAST VISIT
3 - ACTIVE SINCE LAST VISIT
9 - DISTURBANCE, POSSIBLY PETREL ACTIVITY

System 1*	1	2	3	4	5	6			.			7		
System 2#	1	2	3	4	5	6			7			8		
Booming Site	10	09	08	49	07	12	41	50	14	42	43	19	20	21
01NOV90	0	0	3	.	2	.	.	.	.	.	.	0	0	3
02NOV90	0	2	3	0	0	0	0	.	0	0	0	0	0	3
03NOV90	0	0	3	0	0	.	.	.	.	.	.	0	0	3
04NOV90	0	0	3	0	3	0	0	.	0	0	0	0	0	3
05NOV90	0	0	0	0	0	.	.	.	.	.	.	0	2	3
06NOV90	0	0	.	.	.	.	.	.	.	.	.	.	.	.
07NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3
08NOV90	0	0	3	0	3	0	0	.	0	0	0	0	0	3
09NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3
10NOV90	0	0	3	.	3	.	.	.	.	.	.	0	2	3
11NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3
12NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13NOV90	0	0	0	0	3	0	0	.	0	0	0	0	0	3
14NOV90	3	0	0	0	3	.	.	.	.	.	.	0	0	3
15NOV90	3	0	0	.	3	.	.	.	.	.	.	0	0	3
16NOV90	0	3	3	0	3	.	.	.	.	.	.	0	0	3
17NOV90	0	0	3	0	3	0	.	.	0	.	.	0	0	3
18NOV90	0	0	3	.	3	.	.	.	.	.	.	0	0	3
19NOV90	0	0	3	.	3	.	.	.	.	.	.	0	0	3
20NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	0
21NOV90	0	3	3	0	3	.	.	.	.	.	.	0	0	.
22NOV90	0	0	3	.	3	.	.	.	.	.	.	0	0	0
23NOV90	0	0	3	0	3	0	.	.	0	.	.	0	0	0
24NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	0
25NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3
26NOV90	0	.	3	0	3	.	.	.	.	.	.	0	0	3
27NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3
28NOV90	0	2	3	0	3	.	.	.	.	.	.	0	0	3
29NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3
30NOV90	0	0	3	0	3	.	.	.	.	.	.	0	0	3

System 1*	8		9	11		12			.	13		14	15			17		
System 2#	9		10	11		12			13	14		15	16			17		
Booming Site	23	24	25	35	45	26	27	40	44	33	36	31	16	17	18	47	48	
01NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	0	.	.	.	01NOV90
02NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	0	3	3	3	02NOV90
03NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	03NOV90
04NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	3	3	04NOV90
05NOV90	.	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	3	05NOV90
06NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	06NOV90
07NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	3	07NOV90
08NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	0	3	3	3	08NOV90
09NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	09NOV90
10NOV90	.	0	0	0	0	0	0	0	.	.	.	.	.	.	.	3	3	10NOV90
11NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	11NOV90
12NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12NOV90
13NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	3	3	0	0	13NOV90
14NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	14NOV90
15NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	15NOV90
16NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	16NOV90
17NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	0	0	17NOV90
18NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	18NOV90
19NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19NOV90
20NOV90	.	3	2	0	0	0	0	0	0	0	0	2	.	.	.	0	0	20NOV90
21NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	21NOV90
22NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	22NOV90
23NOV90	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	3	3	23NOV90
24NOV90	.	3	0	.	.	.	.	.	.	.	.	.	.	.	.	0	0	24NOV90
25NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	25NOV90
26NOV90	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	26NOV90
27NOV90	.	3	0	.	.	.	.	.	.	.	.	.	.	.	.	0	0	27NOV90
28NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	28NOV90
29NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	29NOV90
30NOV90	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	30NOV90

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3 - ACTIVE SINCE LAST VISIT
9 - DISTURBANCE, POSSIBLY PETREL ACTIVITY

System 1*	1	2	3	4	5	6			.			7			8		9	11		12			.	13		14	15			17		
System 2#	1	2	3	4	5	6			.			8			9		10	11		12			13	14		15	16			17		
Booming Site	10	09	08	49	07	12	41	50	14	42	43	19	20	21	23	24	25	35	45	26	27	40	44	33	36	31	16	17	18	47	48	
01DEC90	.	.	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	01DEC90
02DEC90	0	0	3	0	3	3	2	3	0	0	0	0	1	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	2	0	0	02DEC90
03DEC90	.	0	3	0	3	.	.	.	.	.	.	0	0	3	.	3	0	3	3	0	3	0	0	3	0	3	.	.	.	0	0	03DEC90
04DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	04DEC90
05DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	0	3	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	05DEC90
06DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	06DEC90
07DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	07DEC90
08DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	08DEC90
09DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	09DEC90
10DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	10DEC90
11DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	11DEC90
12DEC90	0	0	3	0	3	2	3	3	0	0	0	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	2	0	0	12DEC90
13DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	0	0	13DEC90
14DEC90	0	0	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	14DEC90
15DEC90	0	2	3	0	3	.	.	.	.	.	.	0	0	3	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	0	0	15DEC90
16DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	0	.	.	.	.	.	.	.	.	.	.	.	.	0	0	16DEC90
17DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	0	2	3	2	3	3	.	.	.	.	.	.	.	0	0	17DEC90
18DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	18DEC90
19DEC90	0	3	3	0	3	3	2	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	2	0	0	19DEC90
20DEC90	0	3	3	.	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20DEC90
21DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	0	3	3	0	3	0	3	3	0	3	.	.	.	.	.	21DEC90
22DEC90	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22DEC90
23DEC90	0	3	3	.	3	3	0	2	0	0	0	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	.	.	23DEC90
24DEC90	0	3	3	.	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24DEC90
25DEC90	.	3	3	0	3	.	.	.	.	.	.	2	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	25DEC90
26DEC90	0	3	3	.	3	.	.	.	.	.	.	0	0	3	.	3	0	0	3	0	3	0	0	3	0	3	.	.	.	.	.	26DEC90
27DEC90	0	3	3	.	3	.	.	.	.	.	.	0	0	3	.	3	0	0	0	0	0	0	0	3	0	3	.	.	.	.	.	27DEC90
28DEC90	0	3	3	.	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28DEC90
29DEC90	.	3	3	2	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	0	29DEC90
30DEC90	0	3	3	0	3	9	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	30DEC90
31DEC90	0	3	3	0	3	0	0	3	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	.	.	31DEC90

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System 1*	1	2	3	4	5	6			.			7			8		9	11		12			.	13		14	15			17		
System 2#	1	2	3	4	5	6			7			8			9		10	11		12			13	14		15	16			17		
Booming Site	10	09	08	49	07	12	41	50	14	42	43	19	20	21	23	24	25	35	45	26	27	40	44	33	36	31	16	17	18	47	48	
01JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	01JAN91
02JAN91	0	3	3	.	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	02JAN91
03JAN91	0	3	3	0	3	3	0	3	.	.	.	0	0	3	.	3	0	0	0	0	3	0	0	3	0	3	.	.	.	.	.	03JAN91
04JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	04JAN91
05JAN91	0	3	3	0	3	3	0	3	0	0	0	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	0	0	05JAN91
06JAN91	0	3	3	0	3	.	.	0	.	.	.	0	0	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	06JAN91
07JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	3	0	0	3	3	3	0	0	0	3	3	3	.	.	.	0	0	07JAN91
08JAN91	0	3	3	0	3	2	.	3	.	.	.	0	0	3	.	.	.	0	0	.	.	.	.	.	.	.	.	.	.	0	0	08JAN91
09JAN91	0	3	3	0	3	3	0	3	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	0	0	0	09JAN91
10JAN91	0	3	3	0	3	3	0	3	.	.	.	2	3	3	.	.	.	.	.	.	.	.	.	.	.	.	0	3	.	0	0	10JAN91
11JAN91	0	3	3	0	3	.	.	.	.	.	.	2	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	11JAN91
12JAN91	0	3	3	0	3	.	.	.	.	.	.	0	3	3	3	0	0	0	0	0	0	.	0	3	0	3	.	.	.	0	0	12JAN91
13JAN91	0	3	3	3	3	.	.	.	.	.	.	2	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	13JAN91
14JAN91	0	3	3	3	3	.	.	.	.	.	.	2	3	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	14JAN91
15JAN91	0	3	3	0	3	3	0	3	0	0	0	0	0	3	3	.	.	.	.	.	.	.	.	.	.	.	0	3	0	0	0	15JAN91
16JAN91	0	3	.	0	.	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	16JAN91
17JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	17JAN91
18JAN91	0	3	3	0	3	3	0	.	.	.	.	0	0	3	.	3	0	0	3	0	0	.	0	3	0	3	0	3	0	0	0	18JAN91
19JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	0	2	3	0	9	0	0	3	0	3	.	.	.	0	0	19JAN91
20JAN91	0	3	3	3	3	.	.	.	.	.	.	0	0	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	20JAN91
21JAN91	0	3	3	3	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	21JAN91
22JAN91	0	3	3	3	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	22JAN91
23JAN91	0	3	3	3	2	.	.	.	.	.	.	0	0	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	23JAN91
24JAN91	0	0	3	0	2	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	24JAN91
25JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	25JAN91
26JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	26JAN91
27JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	27JAN91
28JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	3	0	0	3	0	0	0	0	3	0	3	.	.	.	0	0	28JAN91
29JAN91	0	3	3	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	29JAN91
30JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	30JAN91
31JAN91	0	3	3	0	3	.	.	.	.	.	.	0	0	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	31JAN91

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System 1*	1	2	3	4	5	6	.	7	8	9	11	12	.	13	14	15	17	
System 2#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Booming Site	10	09	08	49	07	12 41 50	14 42 43	19 20 21	23 34	25	35 45	26 27 40	44	33 36	31	16 17 18	47 48	
01FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	01FEB91
02FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	02FEB91
03FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	03FEB91
04FEB91	0	3	3	0	3	3 0 0	0 0 0	0 0 3	0 .	.	. .	. . .	.	. .	.	0 3 0	0 0	04FEB91
05FEB91	0	3	3	0	3	3 . .	. . .	0 0 3	. 3	0	0 3	0 0 0	0	3 0	3	0 3 0	0 0	05FEB91
06FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. 3	0	0 3	0 0 0	0	3 .	3	. . .	0 0	06FEB91
07FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	07FEB91
08FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	08FEB91
09FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	09FEB91
10FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	10FEB91
11FEB91	0	3	3	0	3	3 0 0	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	0 3 0	. .	11FEB91
12FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	12FEB91
13FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	13FEB91
14FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	14FEB91
15FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. 3	0	0 3	0 3 0	0	3 0	3	. . .	. .	15FEB91
16FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. 3	0	0 0	0 3 .	0	3 0	3	. . .	. .	16FEB91
17FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	17FEB91
18FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	18FEB91
19FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	19FEB91
20FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	20FEB91
21FEB91	0	3	3	0	3	3 0 0	0 0 0	0 0 3	. .	.	. .	. . .	.	. .	.	0 3 0	. .	21FEB91
22FEB91	0	3	3	0	3	3 0 0	0 0 0	0 0 3	. .	.	. .	. . .	.	. .	.	0 3 0	. .	22FEB91
23FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	23FEB91
24FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	24FEB91
25FEB91	0	3	3	.	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	25FEB91
26FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	26FEB91
27FEB91	0	3	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	27FEB91
28FEB91	0	3	3	0	3	3 0 2	. . .	0 0 3	. 3	.	. .	. . .	.	. .	.	0 3 0	0 0	28FEB91

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KEY:
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1 - SOME RECENT ACTIVITY
2 - SOME DISTURBANCE SINCE LAST VISIT
3 - ACTIVE SINCE LAST VISIT
9 - DISTURBANCE, POSSIBLY PETREL ACTIVITY

System 1*	1	2	3	4	5	6	.	7	8	9	11	12	.	13	14	15	17	
System 2#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Booming Site	10	09	08	49	07	12 41 50	14 42 43	19 20 21	23 24	25	35 45	26 27 40	44	33 36	31	16 17 18	47 48	
01MAR91	0	2	3	0	3	. . .	. . .	0 0 3	. 0	0	2 3	0 3 .	0	3 0	3	. . .	0 0	01MAR91
02MAR91	0	3	3	.	3	. . .	. . .	0 0 3	. 3	0	0 0	0 0 .	0	0 0	0	. . .	. .	02MAR91
03MAR91	0	3	0	0	3	. . .	. . .	0 0 3	. 3	.	. .	. . .	.	. .	.	. . .	0 0	03MAR91
04MAR91	.	3	3	0	3	. . .	. . .	0 0 3	. 3	0	. .	. . .	.	. .	.	. . .	0 0	04MAR91
05MAR91	0	3	3	.	3	3 . 2	. . .	0 0 3	. 3	0	. .	. . .	.	. .	.	0 3 0	. .	05MAR91
06MAR91	0	3	3	0	3	3 0 0	. . .	0 0 3	. 3	.	. .	. . .	.	. .	.	0 3 .	0 0	06MAR91
07MAR91	0	3	3	0	3	. 0 0	. . .	0 0 3	. 3	0	. .	. . .	.	. .	.	. . .	. 0	07MAR91
08MAR91	0	3	3	.	2	. . .	. . .	0 0 3	. 3	0	0 0	0 3 .	0	3 0	3	. . .	. .	08MAR91
09MAR91	0	3	3	.	0	. . .	. . .	0 0 3	. 3	0	0 0	0 0 .	0	3 0	3	. . .	. .	09MAR91
10MAR91	0	3	3	.	3	. . .	. . .	0 0 3	. 3	0	. .	. . .	.	. .	.	. . .	. .	10MAR91
11MAR91	0	3	3	0	3	3 . 0	. . .	0 0 3	. 3	.	. .	. . .	.	. .	.	. . .	0 0	11MAR91
12MAR91	0	0	3	0	3	. . .	. . .	0 0 3	. 3	0	. .	. . .	.	. .	.	. . .	0 0	12MAR91
13MAR91	0	3	3	0	3	. . .	. . .	0 0 3	. 3	0	. .	. . .	.	. .	.	. . .	0 0	13MAR91
14MAR91	0	0	3	0	3	. . .	. . .	0 3 3	. 3	.	. .	. . .	.	. .	.	. . .	0 0	14MAR91
15MAR91	0	0	3	0	3	. . .	. . .	0 3 3	. 0	.	. .	. . .	.	. .	.	. . .	0 0	15MAR91
16MAR91	0	2	3	0	3	. . .	. . .	0 0 3	. 0	.	. .	. . .	.	. .	.	. . .	0 0	16MAR91
17MAR91	0	9	3	0	3	. . .	. . .	0 3 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	17MAR91
18MAR91	0	9	3	0	3	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	18MAR91
19MAR91	0	0	3	.	3	2 2 0	0 3 3	0 0 3	. 3	0	0 0	. . 0	.	. .	.	0 0 0	. .	19MAR91
20MAR91	0	0	3	2	3	. . .	. . .	0 0 0	. .	.	. .	. . .	.	. .	.	0 0 .	0 0	20MAR91
21MAR91	0	3	3	.	2	. . .	. 0 .	. 9 3	. 3	0	. .	0 . .	.	. .	.	0 . .	. .	21MAR91
22MAR91	0	0	2	.	0	. . .	. . .	. 9 .	. .	.	. .	0 0 .	0	. .	3	. 0 .	. .	22MAR91
23MAR91	0	3	0	3	2	3 0 0	3 3 3	0 3 3	. .	.	. .	. . .	.	. .	.	0 0 0	0 0	23MAR91
24MAR91	0	0	3	0	2	. . .	. . .	0 3 3	. .	.	. .	. . .	.	. .	.	. . .	. .	24MAR91
25MAR91	0	3	2	0	3	. . .	. . .	2 3 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	25MAR91
26MAR91	0	0	0	.	2	. . .	. . .	0 0 3	. .	.	. .	. . .	.	. .	.	. . .	. .	26MAR91
27MAR91	0	0	3	0	0	. . .	. . .	0 3 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	27MAR91
28MAR91	0	0	0	0	0	. . .	. . .	0 3 3	. .	.	. .	. . .	.	. .	.	. . .	0 0	28MAR91
29MAR91	0	3	3	.	0	. 0 0	. . .	0 3 3	. 2	0	0 0	0 0 0	.	2 0	2	. . .	0 .	29MAR91
30MAR91	0	0	3	3	0	3 . 0	3 0 0	0 3 3	. .	.	. .	. . .	0	. .	.	. . .	. .	30MAR91
31MAR91	.	2	3	0	0	. . .	. . .	0 3 3	. 3	.	. .	. . 0	.	. .	.	. . .	0 .	31MAR91

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9 - DISTURBANCE, POSSIBLY PETREL ACTIVITY

System 1*	1	2	3	4	5	6			.			7			8		9	11		12			.	13		14	15			17		
System 2#	1	2	3	4	5	6			7			8			9		10	11		12			13	14		15	16			17		
Booming Site	10	09	08	49	07	12	41	50	14	42	43	19	20	21	23	24	25	35	45	26	27	40	44	33	36	31	16	17	18	47	48	
01APR91	.	0	0	.	0	.	.	.	.	.	.	9	3	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	01APR91
02APR91	0	0	0	.	0	.	.	.	.	.	.	0	3	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	02APR91
03APR91	0	0	3	0	0	.	.	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	03APR91
04APR91	0	0	3	0	0	.	.	.	.	.	.	0	3	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	04APR91
05APR91	0	0	0	.	0	.	.	.	.	.	.	2	3	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	05APR91
06APR91	0	0	3	.	0	.	.	.	.	.	.	0	0	3	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	06APR91
07APR91	0	0	2	.	0	0	0	0	.	.	.	0	0	0	.	0	0	0	0	0	0	0	0	0	0	3	0	2	0	.	.	07APR91
08APR91	0	0	0	.	0	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	08APR91
09APR91	0	0	0	.	0	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	09APR91
10APR91	0	0	0	.	2	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10APR91
11APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11APR91
12APR91	0	0	0	0	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	12APR91
13APR91	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	13APR91
14APR91	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	14APR91
15APR91	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	0	15APR91
16APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	16APR91
17APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17APR91
18APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18APR91
19APR91	0	0	0	.	0	0	0	0	2	0	2	0	0	0	.	2	0	0	0	0	0	0	0	0	.	0	0	0	0	0	.	19APR91
20APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20APR91
21APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	21APR91
22APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22APR91
23APR91	0	0	0	.	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	23APR91
24APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24APR91
25APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25APR91
26APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	26APR91
27APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27APR91
28APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28APR91
29APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29APR91
30APR91	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	30APR91

Appendix C: Kakapo chick data (Little Barrier Island 1990-91), estimated age (days after hatching) and weight (g).

Chick Name	Age (days)	Weight (g)
Stumpy		
	1	31.6
	4	43.6
	7	86.1
	10	135.1
	13	209.9
	16	327.0
	19	453.0
	22	603.0
	25	723.0
	28	818.0
	31	1043.0
	34	1210.0
	37	1245.0
	40	1290.0
	42	1300.0
	45	1370.0
	50	1520.0
	60	1660.0
	68	1680.0
	74	1670.0
	103	1950.0
Dobby		
	35	824.0
	60	1515.0
	67	1710.0
	74	1777.0
	110	1950.0