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PRELIMINARY RESULTS AND OBSERVATIONS ON NORTH ISLAND KOKAKO PRODUCTIVITY AND ECOLOGY AT MAPARA WILDLIFE RESERVE, KING COUNTRY, JULY 1993-JUNE 1994

by

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CONTENTS

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by
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ABSTRACT

This report describes the results from the fifth year of a five year research programme. The effects of large scale mammal control upon the productivity and survival of the North Island kokako (*Callaeas cinerea wilsoni*) at Mapara Wildlife Management Reserve are discussed.

Survival of 1992/93 fledglings was 92%. Expectancy of further life was 10.6 years for kokako joining the adult population. It was found that 76% of the adult population could be sexed by their tarsometatarsus length measurements. Of four one-year olds which paired this season at least two were females which attempted to breed; both unsuccessfully.

The territorial kokako population increased from 53 to 59 birds during the year. Fifty kokako are now individually colour banded. The density of kokako at Mapara is now 0.044/ha of forest (1 kokako per 22.7 ha). Fifteen pairs were present at the start of the breeding season in early November. This increased to 21 pairs during the season, the highest number of pairs during this study. Nine pairs made 10 breeding attempts. Six first attempts succeeded in raising 10 fledglings. Three first attempts failed, two due to probable predation by ship rats (*Rattus rattus*). Only one pair renested, but this attempt also failed. Observations on diet and movements of kokako are presented.

1. INTRODUCTION

The purpose of this report is to present information gathered about kokako from July 1993 to June 1994 at the Mapara Wildlife Management Reserve. Reports by the same authors describe the previous four years work (Sherley et al. 1991, Flux et al. 1994, Flux et al. 1995). During 1990 to 1992, mammal control at Mapara has involved the use of annual, aerial, 1080 pollard drops (Bradfield 1993). This year Broadifacoum poison in pollard baits was dispensed by feeding stations spaced at approximately

200 m spacings throughout the forest. Brush-tailed possums (*Trichosurus vulpecula*) were reduced to very low numbers whilst ship rats (*Rattus rattus*) were reduced only moderately.

Kokako research at Mapara is part of a national, five-year research by management project started in 1989 (Hay 1991 and Innes 1992). Research supports the North Island kokako recovery plan (Rasch 1992) by collating information on causes of kokako mortality and the outcomes of management techniques. Information on kokako ecology is needed to direct future management.

Fenn traps spaced along ridge tracks throughout the reserve provided some year round mustelid and rat control. Deer were not present and goats and pigs were maintained at very low levels by shooting.

Snap traps (for rats) and leg-hold traps (for possums) were set on the ground, under covers, around all known kokako nests. These provided additional protection against small mammal predation. Mammal control results are not covered by this report.

2. METHODS

2.1 Bands and transmitters

Adult kokako were caught using canopy rigged mist-nets. They were leg-banded with individual combinations of both metal and plastic coloured bands for field identification. Radio transmitters weighing 4-5 g were fitted, using backpack harnesses, to eight adult kokako as an aid in monitoring their breeding. Harnesses were of light nylon cord with a weak link (Flux 1994). The initial breaking strain of cotton weak links was approximately 750 g. Transmitters used were Biotrack and Holohil single stage units with expected lives of ten to twelve months. Ten nestlings were banded at 10-15 days of age. Birds were weighed when banded and tarsometatarsus length of each adult was measured.

When handling birds it was thought possible to distinguish younger birds. Characters such as voice, greater amount of brown in plumage, yellow colour and softness of foot pads and lack of scarring on legs were used in combination to identify young birds. It is not known whether one and two year old birds could be distinguished by these criteria.

2.2 Survey and monitoring

A census of territorial adults was carried out during October 1993. All known territories were checked for occupancy and any banded kokako identified. Areas of the reserve not previously occupied by kokako were surveyed using the standard "walk through" technique (Rasch 1992); taped calls were played at approximate 250 m intervals along ridges. A kokako or pair was considered to be territorial where found if it/they were banded and occupied the same range as last year or were recorded in the same area on at least two separate occasions for a minimum of 15 minutes during which they expressed full song (Innes 1993).

From 1 November 1993 until 1 March 1994, all pair territories were visited weekly. Radio-tagged kokako were located and followed using portable receivers. Non-transmittered birds were usually located while they sang at dawn or, occasionally, by their response to recorded song. Kokako were then followed as inconspicuously as possible. Whenever possible, a minimum of 35 minutes was spent with each pair and any breeding activity recorded. Nests identified were watched weekly to ensure adults were in attendance. Behaviour of adults at nests and the identity of the incubating bird was noted. Abandoned nests were investigated for any signs of the cause of failure. Characteristics of nests and nest sites were recorded.

Movements of banded birds were mapped whenever possible. When an adult kokako had not been sighted for over one year we considered it to probably be dead.

2.3 Diet

Observations of feeding were recorded only when food was clearly identified. Kokako spend much time in epiphytes and forest canopy where they and their foods were rarely identifiable.

2.4 Nest protection

From 10 to 12 each of rat snap-traps and leg-hold possum traps were set around each nest. These remained set throughout the nesting period.

2.5 Phenology

A sample of 15 of each of 9 common kokako food plant species was monitored monthly. Flowering and fruiting parts of each plant were scored on an abundance scale of 0-4.

Table 1 Mapara banded kokako (to March 1992).

Date	Name	Left leg	Right leg	Age + sex (M/F)	Weight (g)	Tarso. (mm)	Tx.	Grid ref.
29/6/79	Skeptic	E130748	W/G	Adult	259	71.8		
11/4/90	Nerak	R	E177101/11	Adult	235	71.7		054 944
10/6/90	L-Nino	W	R/E177103	Adult	249	70.3		067 940
10/6/90	L-Nino 2	Y	R/E177102	Adult	234	69.85		067 940
20/9/90	Rumple	Y/B	R/E177104	Adult	204			093 927
21/9/90	Shreikback	Y/R	Y/E177105	Adult	254			070 940
14/11/90	Swiveltrout	B	Y/E177106	Adult M	242	68.1		090 900
16/11/90	Singleton	B	B/E177107	Adult M	254			068 944
08/2/91	Hinau	E177109	Y	Nestling	180			096 895
19/2/91	Turnpike	R	E177110	Adult M	235			093 899
21/2/91	Archie	W	E177111	Adult	245			086 902
22/2/91	Angel	G	E177112	Adult	219			086 902
31/7/91	Purplerain	G/Y	E117113	Adult M	240	67.9		094 898
03/8/91	Majora	B	E177114	Adult	235	67.8		097 893
04/8/91	Momingglory	W/B	E177115	Adult M	233	67.9		086 903
05/9/91	Marzba	R	G/E177116	Adult	243	66.5	57	092 907
05/9/91	Moro	R/Y	E177117	Adult	210	62.4		092 907
08/9/91	Marama	R	B/E177118	Adult F	223	61.6	59	095 896
11/9/91	Nice	B	R/E177119	Adult M	223	64.8	55	097 904
04/10/91	Gian	W	Y/E177120	Adult	275	67.7	53	098 908
31/10/91	Batagoo.Bird	R/G	E177121	Adult F	191	60.2	39	086 903
06/3/92	Eureka	G	R/E177122	Adult F	225	61.8		093 935
06/3/92	Archimedes	Y	Y/E177123	Adult M	241	67.35		093 935
27/3/92	Sleazy	B/Y	E177124	Adult F	217	63.45		097 904
28/3/92	Cuckoo	R/B	E177125	Adult	222	61.25		097 931
28/3/92	Stinky	G/W	Y/E177126	Adult	212	67.65		097 931

Date = date of capture and banding **E123456 = metal band number**
Colour bands recorded as; red (R), yellow (Y), white (W), blue (B), green (G).
Tarsomet = tarsometatarsus length Tx. = **transmitter frequency**
Grid reference from NZMS 260 map S17

3. RESULTS

3.1 Banding

Between September 1993 and April 1994, 15 adult kokako were mist-netted; 5 of these were recaptures of previously banded birds. Ten nestlings were also banded, all of which subsequently fledged. One of these fledglings was subsequently found with a broken tarsometatarsus and was removed to be reared at the Otorohanga Kiwi House. A total of 51 adult kokako and 29 nestlings has now been banded at Mapara (Tables 1-5). In April 1994, 50 banded adults (and 9 unbanded), plus 9 banded juveniles were known in the population.

3.2 Measurements

Measurements taken this season are presented below (see Tables 4 and 5). Sex, where recorded, was judged from nesting role, (incubation is the exclusive role of the female). Mean weight of 50 adult kokako was 228.8 g, (s = 16.6, range 191-275 g), mean weight of 14 males was 230.9 (s = 11.8, range 209-254 g) and mean weight of 8 females was 212.4 g, (s = 12.5, range 191-225 g).

The mean tarsometatarsus length of 13 male kokako was 67.46 mm, (s = 2.02, range 63.50-70.85 mm) compared with 63.20 mm, (s = 2.12, range 60.20-66.25 mm) for the

Table 2 Kokako captured during the 1992/93 season.

Date	Name	Left leg	Right leg	Age	Weight (g)	Tarso. (mm)	Tx.	Grid ref.	Sex
12/9/92*	Eureka	G	R/E177122	adult	208		30	088 932	F
12/9/92*	Archimedes	Y	Y/E177123	adult	223			088 932	M
15/9/92	Crystal-fire	G	G/E177127	adult	225	66.95	46	095 896	M
19/9/92	Skathe	R/W	13177128	adult	227	68.65	40	093 909	M?
19/9/92	Pinkdot	G/B	13177129	<1 yr.	229	64.85	44	093 909	
22/9/92	Mystar-e	B	G/E177130	Adult	209	67.65	42	088 932	
22/9/92	Matabeelee	W	13/13177131	adult	235	68.65		088 932	
25/9/92*	Nice	B	R/E177119	adult	218	65.00	14	097 904	M
30/9/92	Bamboozled	R	Y/E177133	adult	256	72.20		092 928	
30/9/92	Bosnia	Y	B/E117132	adult	224	67.65	48	092 928	
5/10/92	Duja#	Y	G/E177134	adult	242	69.65	38	098 908	
5/10/92*	Gian	W	Y/E177120	adult	248	68.20		098 908	
1/11/92	Rumpltu	R/Y	R/E177135	adult	215	69.35		092 927	
1/11/92	Stiltskin	W	G/E177136	adult	233	63.80	33	092 927	
2/11/92	Old Holborn	R/B	Y/E177137	adult	212	66.25		099 898	F
4/11/92	Tui	G	B/E177138	adult	232	69.10		099901	M
6/11/92	Ezama	G/Y	R/E177139	adult	205	62.85		098 931	F
6/11/92	Citsat	R/Y	G/E177140	adult	213	63.50		098 931	M
7/11/92	Grimble	G	Y/E177141	adult	209	70.85		092 918	M
16/3/93*	Noddy	B/M	G/B	sub-adult	193	62.55		088 908	
18/3/93	Hemi	G/Y	Y/E177062	adult	241	69.40		099901	

* Indicates previously banded birds recaptured this season.
# Duja had one irregular leg (possibly broken early in life?) measuring 68.65 mm.

8 females measured. The measurements of 3 of the 14 males fell within the observed female range and 2 of 8 female measurements were within the male range.

Weights may vary substantially depending on the contents of the digestive tract and is likely to be strongly linked to overall size and thereby to a measure such as tarsometatarsus length. Kokako over 230 g were invariably male (Fig. 1), but lighter birds could not be assumed to be female.

Tarsometatarsus length provides a useful sexing method for field workers, though the measurement by which we assign sex may vary regionally to some extent. At Mapara, a kokako with a tarsometatarsus length greater than 66 mm is male. If it is smaller than this the bird is generally a female (Fig. 2). Based on these measurements, 76% of kokako for which we know sex based on their nesting behaviour were correctly sexed. It should be borne in mind that skin and scale condition and small differences in how the bird is held can affect the accuracy of this measurement. Kokako captured several times have mostly been remeasured to within 0.5 mm of the original measurement.

Most chick weights were recorded only at the time of banding (Table 3 and 5). The small differences in weights of siblings may reflect order of hatching.

Table 3 Nestlings banded at Mapara during 1992/93, (chicks were banded and weighed at ten to fifteen days).

Date	Name of Parent	Name of Chick	Left leg	Right leg	Weight (g)	Grid ref. (nest)	Sex	Fledged? (Yes/No)
29/12/92	Nice	Freefall	B/E177142	R/Y	152	099 904		captive
29/12/92	Nice	Jumar	B/E177143	G/Y	-	099 904		N
29/12/92	Nice	Karab	B/E177144	R/B	136	099 904		N
4/1/93	Manga	Noddy	B/E177145	G/B	147	104 898		Y
4/1/93	Manga	Big ears	B/E177146	R/W	164	104 898		Y
4/1/93	Eureka	Sweep	B/E177148	B/Y	131	093 935		Y
4/1/93	Eureka	Sooty	B/E177147	WB	146	093 935		Y
12/1/93	Old Hol.	Rizla	G/Y	G/E177051	118	086 898		N
12/1/93	Old Hol.	Rolli	R/B	G/E177052	100	086 898		N
18/1/93	Old Hol.	Runt	R/W	G/E177053	90	086 898		N
21/1/93	Singleton	Opiki	G/E177054	G/Y	125	067 945		Y
4/2/93	Marama	Punk+	B/E177055	G/Y	137	096 896	F	Y
4/2/93	Ezama	Collos+	B/E177056	G/W	138	097 931	F	Y
4/2/93	Ezama	Perm	B/E177057	R/G	131	097 931		Y
3/3/93	Nice	Ganesh	G/E177058	RB	128	097 904		Y
3/3/93	Nice	Vishnu	G/E177059	G/B	148	097 904		Y
3/3/93	Old Hol.	Vulpec	G/E177060	R/W	127	097 898		Y
3/3/93	Old Hol.	Trichos	G/E177061	B/Y	110	097 898		Y

+ Punk and Collos were sexed by incubation role during the 1993/94 season.

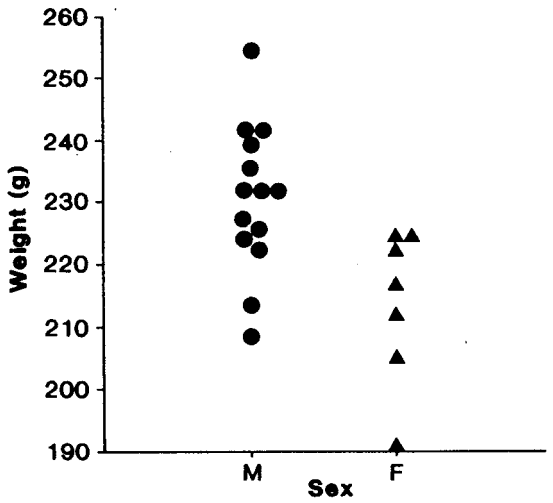

Figure 1 **Weights of known-sex kokako at Mapara.**

3.3 Transmitters

Transmitters were fitted to eight adult kokako (Table 4). Immediately after release most kokako pecked at their bands and transmitters. In two cases (Elc and Asimbonanga) this was sufficient to dislodge the transmitters. The former bit through the harness neck loop within a day or two of its application but retained the transmitter (on its breast) for twelve weeks. In the latter case the bird cut through the neck loop join. Both these shed transmitters were recovered, one was badly damaged by the birds bill, the other was reused. After the first day birds appeared to ignore the devices, no difference was observed in behaviour of marked and unmarked birds within a pair. Some transmitters

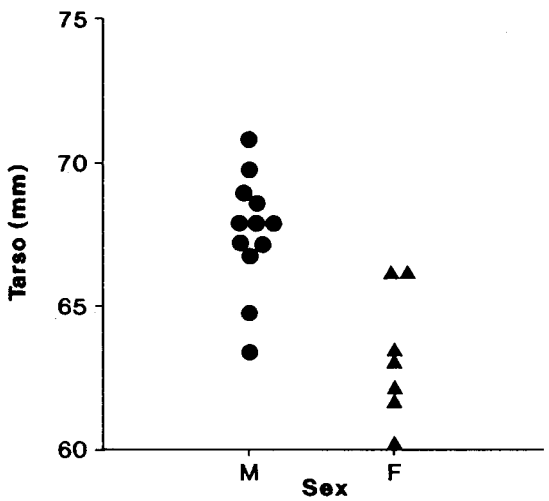

Figure 2 **Tarsometatarsus length of known-sex kokako at Mapara.**

Table 4 Adult kokako captured during the 1993/94 season.

Date	Name	Left leg	Right leg	Weight (g)	Tarsomet. (mm)	Tx.	Grid ref	Sex
25/9/93	Solitaire	G/B	Y/E177065	225	66.10	04	068964	F
29/9/93	Asimbonanga	R/W	Y/E 177066	243	70.50	08	098 927	
29/9/93	Elc	*RB*	R/E177067	211	66.40	06	098 927	
30/9/93	Lockerbie	*GB*	R/E177068	208	61.20		092 928	
4/10/93	Etombi	R/W	R/E177069	232	67.40	25	098 931	M
2/11/93	Duja*	Y	G/E177134	253	70.20	35	098 908	
5/11/93	Zigzag	WB	R/E177070	226	69.85		096 899	M
5/11/93	Old Holborn*	RB	Y/E177137	229	65.10	02	096 899	F
7/11/93	Omania	B/Y	Y/E 177071	253	72.10		063 942	
14/11/93	Punk*	B/M	G/Y	201	63.40	20	092 918	F
17/11/93	Bosnia*	Y	B/E177132	222	68.10	08	092 928	
17/11/93	Rumpltu*	R/Y	R/E177135	208	69.10		902 928	
22/3/94	Menorah	G/W	R/E177082	210	63.85		097 894	
23/3/94	Maddas	R/G	R/E 177083	2.30	63.30		102 931	
24/3/94	Anthelen	W/B	Y/E177084	235	65.00		082 926	

* Indicates previously banded birds recaptured this season.

have been recovered from recaptured kokako; even the 8-10 g transmitters applied last year caused only minimal feather abrasion and no skin damage. Other transmitters have either remained on the birds or have been shed by weak link breakage after battery failure and so could not be recovered.

Transmitters performed well this season with all units functioning for their expected battery life, which extended well beyond the breeding season. Use of radio telemetry

Table 5 Nestlings banded at Mapara during 1993/94 season, (chicks were banded and weighed at ten to fifteen days).

Date	Name of Parent	Name of Chick	Left leg	Right leg	Weight (g)	Grid ref, (nest)	Sex	Fledged? (Yes/No)
28/12/93	Old Hol.	Kneecow	W/E177072	R	140	096901		Y
28/12/93	Old Hol.	Gorgo	W/E177073	B	128	096901		Y
29/12/93	Nice	Noseplug	W/E177074	G	161	097 904		Y
30/12/93	Marama	Kojak	W/E177075	Y	132	096 896		Y
30/12/93	Singleton	Pyrrosia	W/E177076	W	109	074 946		Y
30/12/93	Singleton	Serpens	R/Y	W/E177077	116	074 946		Y
30/12/93	Eureka	Weevil	W/E177078	G/Y	141	088 933		Y
30/12/93	Eureka	Huhu	WIE177079	G/B	132	088 933		Y
30/12/93	Eureka	Hopper	W/E177080	RB	140	088 933		Y
2/2/94	Ezama	Yahdor	W/E177081	R/W	152	097 931		Y

E123456 = metal band number
Colour bands recorded as; red (R), white (W), yellow (Y), green (G), blue (B)

meant one observer could monitor several kokako pairs each day as they were no longer limited by when the birds were singing.

3.4 Population monitoring

3.4.1 Census of territorial adults During October 1993 we found 16 pairs and 21 single kokako holding territories at Mapara (see Table 6 for comparison with previous years). Note that these counts do not include non-territorial kokako. Fifteen of these pairs remained together throughout the season (November to March). One pair (Matabeelee and Rumple) were last seen together on 25 October 1993.

Six new pairs formed during the season, resulting in a total of 21 pairs and 17 singles by 7 January 1994. All but one pair present on, or formed subsequent to, 31 October 1993 remained together throughout the season. The members of one pair (Elc and Lockerbie) split sometime during early February.

3.4.2 Pair composition changes The times each pair were followed for each week are presented below (see Table 9). Gaps in the table are the result of bad weather, or in some cases our inability to locate a pair within their regular range.

Changes in pair composition over the past four years are shown in Table 7. Ten of last years 17 pairs have remained unchanged (in 7 pairs both birds were banded, 2 pairs had one member banded and 1 pair had neither banded, but retained the same range). Another pair, both birds of which were until recently unbanded, may also have remained together although they were not recorded in their previous range until late in the season.

Table 6 Mapara kokako population and breeding October 1989 to March 1994.

	31 Oct 1989	Nov '89- Mar '90	31 Oct 1990	Nov '90- Mar '91	31 Oct 1991 '	Nov 91- Mar '92	31 Oct 1992 '	Nov 92- Mar '93	31 Oct 1993	Nov '93 Mar '94
Total pairs	16	16	17	16	15	16	16	17	16	21
Total single	20 (38.5%)	20 (38.5%)	17 (33%)	16 (33%)	19 (39%)	15 (32%)	14 (28.5%)	18 (34.5%)	21 (39.5%)	17 (29%)
Pairs nesting						6? (40%?)		10 (59%)		9 (43%)
Total nests						6?		14		10
Nests succeed						3 (±50%)		8 (57%)		6 (60%)
Total fledging		0?		5 to 7		7		15		10
Fledglings per brood						2.3		1.9		1.7
Fledglings per pair						0.44		0.88		0.48
Territorial adults	52	52	51	48	49	47	49	52	53	59

Table 7 Changes in composition of identifiable kokako pairs, Mapara, 1991-1994.

1991 JAN DEC	1992 JAN DEC		1993 JAN DEC		1994 JAN DEC
Shriekback & unbanded	Shriekback & unbanded		Shriekback		Shriekback & (NEW) unbanded
Archie & Angel	Archie & Angel		Archie & Angel		Archie & Angel
Rumple & unbanded	Rumple & unbanded	Rumpltu & Stiltskin	Rumpltu & Stiltskin		Rumpltu & Stiltskin
		Mystar-E & Matabeelee	Rumple & Matabeelee		Matabeelee
Nerak & unbanded	Nerak & unbanded				
Skeptik & unbanded	Skeptik & unbanded		Skathe & unbanded		Skathe
Crystalfire & unbanded	Crystalfire & Marama		Crystalfire & Marama		Crystalfire & Marama
	Cuckoo & Stinky		Ezama & Citsat		Ezama & Etombi
			Stinky		Stinky?
					Citsat
	Nice & Sleazy		Nice & Sleazy		Nice & Sleazy
	Morning Glory & Batagooli		Morning Glory		Morning Glory & Collos
			Batagooli & unbanded		Batagooli & Purplerain
	Purplerain		Purplerain		
	Eureka & Archimedes		Eureka & Archimedes		Eureka & Archimedes
Gian & Duja	Gian & Duja		Gian & Duja		Gian & Duja
Swiveltrout	Swiveltrout & unbanded		Swiveltrout & unbanded		Swiveltrout
Singleton	Singleton		Singleton & unbanded		Singleton & Solitaire
Majora	Majora		Majora		Majora & Menorah
Marzba & Moro	Marzba & Turnpike		Turnpike		Turnpike
Turnpike					
	Bamboozled & Bosnia		Bamboozled & Bosnia		Bamboozled & Bosnia
	Old Holborn		Old Holborn & unbanded(= Zig-zag?)		Old Holborn & Zigzag
	Tui		Tui & unbanded	Tui & Hemi	Tui
					Hemi
	Grimble		Grimble		Grimble & Punk
					Asimbonanga & unbanded
					Elc & Lockerbie
					Anthelen & Sweep
					unbanded & Opiki
L-Nino	L-Nino		L-Nino		L-Nino & unbanded
					Maddas & unbanded

Five pairs from last season have lost members. In two pairs both members are still alive: Tui and Hemi now occupy adjacent territories as singles; Ezama repaired with a previously unbanded male kokako and retained her original range, whilst her ex-partner Citsat is now single and apparently non-territorial. Rumple (ex-partner of Matabeelee) has probably died. In the remaining two pairs, unbanded females have disappeared, their banded partners have remained in their previous ranges.

Eleven new pairs formed between August 1993 and February 1994. Four involved fledglings from the 1992/93 season pairing with adults which were singles last season. A further two involved unbanded young kokako, one pairing with a newly banded mate of unknown history, the other with a banded kokako which had been single for at least three seasons. Three new pairings involved unbanded birds of unknown age joining previously single, banded territory holders. One pair involves two banded birds, the male having been previously single and the female having had two different mates in the past two seasons. The remaining new pair were both unbanded and in a poorly known area of the reserve.

Banded birds which were not seen in their expected ranges cannot automatically be considered dead. Some, previous territory holders, remain alive but no longer defend territories and are inconspicuous due to their lack of singing. Citsat, a male, was last seen in its previous territory on 12 March 1993 and was re-sighted on 28 March 1994 close to its former range. Banded, non-territorial, sub-adults were similarly inconspicuous.

3.4.3 Juvenile survival 1992/93 Eleven of the 12 banded nestlings which fledged during the 1992/93 season have been re-sighted during November 1993 to June 1994. Thus, an exceptionally high 92% of fledglings have survived their first winter and reached independence. In addition, juvenile characters were exhibited by two unbanded partners in new pairings this season; it is likely that these were both from the single 1992/93 brood of three which were not banded. At least six kokako of this cohort were paired by June 1994.

3.4.4 Adult mortality and fife expectancy No dead kokako have been found. Summing the number of full months for which each banded kokako has been known to be alive gives a total of 1180 months or 98 banded-bird years. Only 9 banded kokako have died. Thus we can derive an overall mortality rate of 9/98 Which equates to 0.09 deaths per bird year.

Table 8 shows the variation in mortality from year to year. Kokako were banded, and died, throughout each year, thus annual analysis does not fully use the data available (hence the discrepancy between the survival rate given above and that averaged from the five year classes in the table). In particular, note that the one bird previously banded in year one of our study was banded as an adult in 1979 (Hay 1981). Survival rate is one minus the mortality rate which is given by the number dead divided by the sum of newly and previously banded birds for a given year.

Table 8 Mortality and survivorship of Mapara adult kokako.

Year to June...	Newly banded	Previous banded	Dead	Mort. rate	Surv. rate
1990	4	1	1	0.20	0.80
1991	6	4	1	0.10	0.90
1992	15	9	4	0.167	0.833
1993	15	20	2	0.057	0.943
1994	10	34	1	0.023	0.977
			average:	0.12	0.88

Life expectancy (E) can be estimated (Seber 1982) by:

$$E = -1/\ln(\text{survival rate})$$

or by ... $E = 1/(\text{mortality rate}) - 0.5$

Both the above estimations give a mean life expectancy of 10.6 years for kokako entering the territorial adult population.

3.4.5 Kokako ranges Areas of kokako ranges were calculated by drawing minimum area polygons to include all points at which identified pairs were observed during October 1993 to March 1994. Ranges of kokako which we had tracked on five or more occasions (see Table 9) varied from 1.9 ha to 10.4 ha, with the average area being 4.6 ha (n = 19, s = 2.28). Last year we recorded larger ranges (averaging 5.9 ha) but this was based on generally longer follow durations. The greater number of pairs this year meant that we made generally shorter follows of each pair. Several pairs nested soon after tracking was begun in November so the size of their ranges prior to breeding was not recorded. Breeding birds were rarely encountered or followed whilst feeding away from the nest, it appeared that they concentrate their feeding to areas close to the nests. It was again apparent that, as in 1992/93, each pair favoured certain parts of their respective territories; this season we have insufficient data to make estimates of the areas of these core ranges.

Three ranges in the Central block and two in the South block overlapped to a small extent. Six interactions were observed between pairs in these areas and at other territory boundaries. Most interactions involved short chases accompanied by much singing. In an interaction observed between Gian, Duja, Nice, and Sleazy vocalisations were very different to sounds usually made by these birds and sounded more like juvenile calls. On one occasion, after a brief period of singing between two pairs, three of the birds moved and fed together for a further half hour. No interactions observed this year involved physical aggression.

Overall, Mapara has 1350 ha of forest habitat; pair ranges occupy about 96 ha and singles (estimated at 5 ha/bird) 85 ha. Thus kokako ranges account for only about 181 ha or 13.4% of the forest area. Again, this is slightly lower than estimated last year despite the greater numbers of birds. We attribute this to the lesser time spent mapping birds' ranges. Not all forest area is suitable kokako habitat; currently all Mapara kokako ranges are centred about prominent ridges. Density of the population is 0.015 pairs per

Table 9 Duration of tracking of kokako pairs at Mapara (in minutes) during the 1993/94 season.

Week ending	1993								1994									Season total
	7 Nov	14 Nov	21 Nov	28 Nov	5 Dec	12 Dec	19 Dec	26 Dec	2 Jan	9 Jan	16 Jan	23 Jan	30 Jan	6 Feb	13 Feb	20 Feb	27 Feb	
Archie & Angel		P 43m	P 36m	P 59m	P 78m	P 56m	P 40m	P 60m	P 55m	P 40m	P 68m	P 61m	P 36m	P 50m	P 35m			717m
Crystalf. & Marama	P 120m	P 29m	P 33m	P 30m	nest	nest	nest	chicks?	1 chick	1 chick	i chick	fledge	P + juv		p + juv			212m
Nice & Sleazy	P 180m	P 35m		nest	nest	nest	chicks?	chicks?	1 chick	fledge	injured	P 10m	P 51m	S 30m	P 37m	P 33m	P 20m	396m
Old Hol. & Zigzag	P 60m	P 120m	P 47m	P 30m	nest	nest	nest	chicks?	2 chicks	2 chicks	2 chicks	fledge	P + juvs	P + juvs	P + juvs			257m
Grimble & Punk		P 43m		P 85m	P 75m	P 35m	nest	FAILS	renest	nest	nest	nest	fails	P 55m		P 57m		350m
Gian & Duja	P 120m	P 67m	P 30m		P 37m	P 120m	P 50m	P 24m	P 65m	P 44m	S 90m	P 40m	P 49m	P 35m	P 49m			820m
Morning G. & Collos						P 129m	nest	nest	fails	P 60m	P 30m+	P 44m	P 25m	P 35m	P 35m	S? 60m	P 35m	453m
Purpirn & Batagooli									nest	nest	nest	nest	fails	P 28m	P 33m	P 45m		106m
Ezama & Etombi	P 24m	P 35m	P 60m	P 30m	P 92m+	P/S ?	P 51m+	P 55m	nest 3egg	nest	nest	nest	1 chick	1 chick	1 chick	fledge		235m
Rumpltu & Stiltskin	P 36m		P 35m	P 45m	P 80m	P 76m	P 47m	P 27m	P 38m	P 23m	P 52m	P 35m	P 40m	P 35m	P 30m			599m
Eureka & Archim.		P 60m	P 37m	nest	nest	nest	nest	chicks?	3 chicks	3 chicks	3 chicks	fledge		P +3juvs	P 48m			145m
Asimbo. & Kalim		P 60m	P 36m		P 46m	P 60m	P 26m	P 42m	P 32m	P 35m	P 42m	P 110m	P 24m	P 26m	P 85m			624m
Elc & Lockerbie				P 145m	S 20m	P 35m	P 30m	S 70m	P 26m	P 36m	P 30m	S 31m	S 28m		S 36m	P splits		487m
Bamboozl. & Bosnia		P 34m	P 35m	P 120m	P 190m	P 125m	P 45m	P 60m	P 37m	P 38m	P 60m	P 21m	P 51m	P 51m	P 35m			902m
Anthelen & Sweep				P 11m				P 65m	P 30m	P 30m	P 48m		P 44m	P 35m	P 35m			298m
Majora & Menorah									P 75m		P 82m	P 35m	P 50m	P 37m	P 26m			305m
Singleton & Solit.	P 33m	P 33m	P 46m	P 26m	P45 nest	nest	nest	chicks?	2 chicks	2 chicks	2 chicks	2 chicks	3 fledge	P +juvs	P + juvs			183m
Pili & Opiki			P 80m	P 46m	P 130m	P 45m	P 40m	P 30m	P 35m	P 30m	P 43m	P 71m	P/S 35m	P 82m	P 20m+			687m
L-Nino & Racino	P 40m	P 8m	P 62m	P 53m	P 70m	P 30m+	P 57m	P 35m	P 47m	P 31m	P 31m	P 40m	P 35m	P 55m	P 45m			639m
Shriekb. & Shelayl.										P 30m	P 70m	P 40m	P 20m	P 27m	P 35m			222m
Maddas & Tafara										P 65m	P 110m		P 80m	P 20m	P 10m			285m

P = pair S = single

hectare, and a total of 0.044 kokako per hectare. These measures equate to one pair to every 66 ha and one bird to every 23 ha of the reserve's forested area.

3.5 Breeding

3.5.1 Locating nests Three female kokako fitted with radio-transmitters led us directly to their nests. All other nests located this season were located through observation of the birds' behaviour. Although birds were seen carrying material, no nests were located during the building stage. That incubation is carried out by the female only has been verified by observations of captive kokako (P Moreton pers. com.). Lengthy follows of the male alone usually signify the onset of incubation. Females leave their nests briefly to feed, usually at least once every two hours. The male returns to feed the female on the nest every 20 to 90 minutes and can thus be followed to locate nests. Food passing to the sitting female can be very rapid and easily overlooked if the nest is concealed. In such cases it was repeated visits by the male to a certain tree, or sightings of the female moving which lead to the discovery of a nest.

3.5.2 Nesting attempts Fourteen pairs were followed weekly throughout the nesting season. Among this group a nesting attempt could only have been missed if the attempt had failed within a week of initiation. One pair (Elc and Lockerbie) were often apart and only single birds were observed during weekly follows, however, there was no indication of nesting. A further six pairs were formed during the season and may have been together, unmonitored, for several weeks. It is quite possible that unsuccessful nesting attempts were made before we detected these pairs.

At least 9 pairs of kokako made 10 recorded nesting attempts (Tables 10 and 11). Only one pair (Punk and Grimble) made a second nesting attempt after losing their first nest, compared to four pairs last year.

This year a smaller proportion (43%) of pairs attempted to breed than last year, when 59% of pairs made an attempt. Of pairs which made no breeding attempts, at least three were established pairs, none of which have made any breeding attempts in the past three years. Seven non-breeding pairs were newly paired this season.

Table 10 Outcome of nesting attempts at Mapara, 1993/94.

Parent	Date found	Fate
Nice & Sleazy	22/11/93	One chick fledged by 9/1/94, chick broke leg, removed to captivity
Eureka & Archimedes	27/11/93	Three chicks fledged by 18/1/94
Old Holbom & Zigzag	29/11/93	Two chicks fledged by 19/1/94
Singleton & Solitaire	1/12/93	Two chicks fledged by 27/1/94
Crystalfire & Marama	4/12/93	One chick fledged by 17/1/94
Grimble & Punk	16/12/93	Failed, at least two eggs eaten by rat 17-21/12/93
Morning Glory & Collos	18/12/93	Failed, two eggs eaten by rat 24-27/12/93
Ezama & Etombi	29/12/93	Three eggs yield one chick. Fledged by 18/2/94
Purplerain & Batagooli	2/1/94	Failed by 24/1/94, unknown cause
Punk & Grimble (renest)	2/1/94	Failed by 25/1/94, unknown cause

Table 11 Calendar of nesting events for Mapara kokako 1993/1994.

	1993						1994												
Week ending	21 Nov	28 Nov	5 Dec	12 Dec	19 Dec	26 Dec	2 Jan	9 Jan	16 Jan	23 Jan	30 Jan	6 Feb	13 Feb	20 Feb	1 Mar	1 Apr	1 May	1 Jun	1 Jul
Parents																			
Nice & Sleazy		I	I	I	C?	C	1C	1F							lost				
Eureka & Archimedes		I	I	I	C?	C?	3C	3C	3C	3F					3F	left			
Old Holborn & Zigzag			I	I	I	C?	2C	2C	2C	2F					2F	left			
Singleton & Solitaire			I	I	I	C?	2C	2C	2C	2C	2F				2F	2F	2F	left	
Crystalfire & Marama			I	I	I	C?	1C	1C	1C	1F					1F	1F	1F		left
Grimble & Punk					I	L	I	I	I	I	L								
Morning Glory & Collos					I	I	L												
Ezama & Etombi						I	I	I	C?	C	C	1C	1C	1F	?	?	?		left
Purplerain & Batagooli							I	I	I	L									

B = building I = incubating C = chicks present L = nest lost/preyed on
F = fledglings present lost = fledgling removed to captivity left = fledgling(s) no longer present with parents in natal range

The timing of nesting attempts was very similar to last year, with first nests occurring in the last week of November and first week of December. Of the five pairs which bred both this year and last, four nested within a calender week of last seasons nesting times and the fifth was only two weeks different in its timing. Ezama (a female) which nested in the same territory as last year, but with a new mate, also nested within a week of last years timing: nesting during late December/early January in both years.

3.5.3 Nest fates Six of the 10 attempts (60%) succeeded in producing 10 fledglings (Table 10) in 3 broods of one, 2 broods of two, and 1 brood of three. The average brood size this season was 1.7 at fledging. Average brood size from 17 successful nests over the past 3 years was 1.9 at fledging.

Three first attempts and one second attempt failed. All were nests of new pairs. Two clutches were probably preyed on by rats during early incubation. (Rat scavenging immediately following failure due to other causes could not be distinguished from rat predation!) In both cases the remnants of at least two egg shells were ragged edged and rat droppings were found in the nests. In one of these nests there were also snagged rat fur and chewed insect remains. Both of the other nest losses occurred at about the predicted date of hatching. In one nest a few tiny shell chips indicated that hatching had occurred before predation or desertion. No sign was found in either nest to indicate a likely predator; one nest-bowl appeared disturbed, but the other was intact.

3.5.4 Nest descriptions Nest height varied from 5 to 32 m, with a mean height of 13 m (n = 10, s = 9.5). Nests were found in the following host tree species: 2 nests in tawa (*Beilschmiedia tawa*), 2 were in hinau (*Elaeocarpus dentatus*), 3 in mahoe (*Melicytus ramiflorus*) and 1 nest in each of, wheki (*Dicksonia squarrosa*), rimu (*Dacrydium cupressinum*) and totara (*Podocarpus totara*).

No pattern was observed in choice of nesting sites. No birds re-used nest sites from previous years, although one pair built their nest in the same tree and two in neighbouring trees to their last year's nests. In general, pairs chose sites with similar vegetation cover as they chose last year. All pairs which made simple nests in epiphyte clumps last year used this technique again. One pair, which last year built a twig platform nest, this year used an epiphyte site. Height of nest sites has shown considerable variation each year of the study, but the mean height of 26 nests measured is 14 m (s = 9). Nests were sited on ridges, valley sides and bottoms, and had many different aspects.

All nests were well concealed. Asteliads (*Astelia* spp., *Collospermum* spp.) provided the main cover over four nests. Others were generally well concealed by the host tree foliage or lianes. All but one nest had more than 70% overhead cover, the other had moderate cover above (50%). Lateral and underneath cover was dense (>70%) at seven sites, one site was well concealed (>70%) from below and moderately well (50%) to the sides and the remaining two nests had moderate to sparse cover below and laterally.

Seven nests were constructed on a foundation platform of interwoven twigs and moss. The remaining three nests were situated in hollowed-out *Collospermum* bases and used no, or few, twigs. In two nests no lining could be seen. In all other nests, the bowl was

lined with fine plant material, including mosses, lichens and liverworts (all nests), asteliad/grass leaf fibres in 5 nests and *Cyathea* spp. tree-fern scales (6 nests). The nest bowl of Purplerain had chewed, rotten wood, and that of Singleton had a few small climbing rata twigs. Two nests had the climbing fern *Pyrrosia serpens* around their rims. The nest bowls were generally quite deep (~8 cm) and about 15 cm in diameter.

3.5.5 Behaviour at nests Less time was spent observing nests this year. Nest visits were intended primarily to record nest fates, but incidental observations are reported here.

Where identified, only female kokako were involved in the building of nests and incubation. During the first three weeks of incubation females remained on their nests for periods ranging from 13 to 137 minutes (mean = 55., s = 44, n = 7). Absences of females from nests during this period were from 4 to 25 minutes (mean = 11., s = 5, n = 29). During this same period males visited nests every 4 to 71 minutes (mean = 30., s = 23, n = 10). Note that because most of our nest watches aimed to record only whether or not a nest was occupied, we would have missed most of the longer male absences.

Weeks 4 to 5 of nesting were characterised by males visiting more frequently and females spending greater periods off, and shorter periods on, the nest. The mean time between male visits was then 16 minutes (s = 5, n = 8). Females spent little time brooding on nests, in most observations they came and left rapidly: brood times of 12, 22, and 21 minutes were observed. Females were absent from their nests for a mean of 15 minutes (s = 6, n = 7) indicating that they remained nearby.

Late in the nesting cycle both parents showed nearly equal activity at the nest. In most cases pairs now foraged together and returned as a pair to feed chicks. Observers did not record faecal sacs being removed as was noted last year. Again this is probably a reflection of less time being spent by observers at nests. As reported last year, adults regularly approached nests by moving along the ground and then climbing to the nest. This behaviour was observed at four nests including one nest which was 22 m up a rimu.

We did not visit nests frequently enough to get detailed information on the length of incubation or nestling periods. From weekly visits we have minimum and maximum estimates for the total nesting period in six nests:

Crystalfire	41 to 55 days
Nice	42 to 59 days
Old Holborn	51 to 62 days
Eureka	46 to 63 days
Singleton	48 to 58 days
Ezama	49 to 57 days

3.5.6 Movement of fledglings and juveniles The fledgling of Nice and Sleazy was found with a broken tarsometatarsus one week after fledging. It was transferred to the Otorohanga Kiwi House. All other fledglings were observed with their parents. Two chicks from the Old Holborn nest were still with their parents 50 days after fledging.

Two months after fledging one of these birds was seen more than 3 km from its natal territory. At least two of the Eureka nest fledglings were still together near their natal range two months after fledging, but were not seen there subsequently. Both Singleton nest fledglings were still with their parents three months after fledging. The single juvenile of Crystalfire was with its parents three and a half months after fledging.

3.5.7 Juvenile kokako characteristics Observations of juvenile characters concur with those reported last year. No nestlings were seen before they reached 10-15 days of age. When banded at 10-15 days the chicks were well covered in dark-grey down, with near-black tail rectrices and primaries beginning to elongate. Wattles at this age were concave, wrinkled and blotched with lilac/purple veins, especially about their margins. The chick of Ezama was likely to have been a few days older than other chicks banded and had blue/lilac wattles.

At fledging, the tails are about three-quarters adult length and most down has been replaced by contour plumage. Tufts of down were noted on the heads of some fledglings during the first week out of the nest. All fledglings were noted to have concave pink wattles; this is certainly the most reliable character for distinguishing fledgling kokako from adults. The calls of juveniles were again found to be quite distinctive; squeaky or warbled mews and broken, squeaky renditions of adult song. It was, however, noted that at times adults do make calls which sound very similar. In one case an adult, paired to a sub-adult which regularly used juvenile calls, often responded to its mate with similar calls. Fledglings were generally inactive during the first week out of the nest and roosted inconspicuously near nesting areas while waiting to be fed. By two weeks after fledging juveniles followed parents quite closely and were still mostly fed by their parents. Juveniles were seen to experiment with various foods at about this time and subsequently spent progressively more time foraging for themselves as they moved about with their parents.

3.6 Diet

3.6.1 Adult foods Observations of feeding were recorded during follows when the food consumed was clearly seen. Observations are, therefore, biased toward feeding in open, low growing species such as shrub-hardwoods. Kokako spent much time amongst epiphytes and canopy foliage where they and their foods were rarely identifiable. In many cases the food most apparent to the observer was not in fact what was being sought. Small insects were taken very rapidly, often before the observer could see the prey. Hence we have recorded more feeding on large insect species which the birds could not swallow intact.

Food types eaten are summarised into two-monthly periods for all feeding observations recorded during 1993/94 (Table 12, Fig. 3-5). In contrast to the past two years, pigeonwood fruit remained available throughout the winter and was still a major item of diet in spring. This season's pigeonwood crop was already ripening whilst the remains of last season's crop was still on some trees. Thus pigeonwood fruit was available, and utilised, throughout the year. Pigeonwood leaves were again eaten extensively during November; this species is the most important in the diet of Mapara kokako and comprised 29% of all feeding observations. *Asplenium flaccidum* fronds

were the most important vegetative element eaten but were eaten little after early January when fruits of other plants became more important.

Between January 1991 and March 1994 we recorded 448 feeding observations. Food items consisted of 41% fruits or seeds, 35% foliage, 16% invertebrates, 7% flowers or floral parts and 2% mosses, liverworts and lichens. A more detailed study of kokako diet at Mapara reports similar dietary proportions (Hay 1981). Foliage provided a similar proportion of the total diet throughout the year whereas other food types varied both seasonally and annually in their availability and proportional contribution to the kokako diet (Fig. 3-5).

Table 12 Foods recorded for kokako during the 1993/94 season.

1993		
July/August	**September/October**	**November/December**
PIGEONWOOD (LEA) (2 / 1)	TAWA (LEA) (1 / 1)	PUKA (nLEA) (1 / 1)
(RFT) (5 / 5)	PIGEONWOOD (RFT) (7 / 6)	(LEA) (1 / 1)
SUPPLEJACK (RFT) (3 / 3)	(yLEA) (1 / 1)	TAWA (LEA) (2 / 2)
CLEMATIS SP. (SEE) (1 / 1)	PUKA (nLEA) (1 / 1)	(SHT) (2 / 2)
PATE (RFT) (1 / 1)	SUPPLEJACK (RFT) (2 / 2)	PIGEONWOOD (LEA) (6 / 5)
REWAREWA (SEE) (1 / 1)	TARATA (LEA) (1 / 1)	(RFT) (4 / 4)
ASPLENIUM FLAC (FR) (3 / 3)	(RFT) (1 / 1)	CLEMATIS FOE (LEA) (1 / 1)
INVERTBRATES:	EARINA SP (LEA) (1 / 1)	EARINA MUC (FLW) (3 / 3)
– bagmoth (1 / 1)	ASPLENIUM FLAC (FR) (4 / 4)	EARINA SP (LEA) (1 / 1)
	INVERTEBRATES:	HINAU (FLW) (2 / 2)
	– scale insect (1 / 1)	REWAREWA (NEC) (4 / 4)
	– bagmoth (3 / 3)	MATAI (SHT) (1 / 1)
		FUCHSIA EXC (LEA) (1 / 1)
		MAPAU (RFT) (1 / 1)
		ASPLENIUM FLAC. (FR) (6 / 6)
		MOSS CAPSULES (1 / 1)
		INVERTEBRATES:
		– bagmoth (2 / 2)
		– winged insect (1 / 1)

	1994	
	January/February	**March/April**
LEA = leaf (n = new, m = mature, y = yellow)	TAWA (SHT) (2 / 2)	PIGEONWOOD (RFT) (2 / 2)
FR = frond SEE = seed	PUKA (LEA) (1 / 1)	RATA (NEC) (1 / 1)
FBU = flower bud	KARAMU (nLEA) (1 / 1)	SUPPLEJACK (RFT) (1 / 1)
SHT = shoot FLW = flower	KIEKIE (RFT) (1 / 1)	HINAU (RFT) (1 / 1)
FRT = fruit NEC = nectar	REWAREWA (UFT) (1 / 1)	MAHOE (RFT) (2 / 2)
RFT = ripe fruit	WINEBERRY (UFT) (1 / 1)	
UFT = unripe fruit	(RFT) (4 / 4)	INVERTEBRATES:
(x/y) : X = Total number of observations of kokako taking this food	MATAI (MALE CONE) (1 / 1)	– bagmoth (1 / 1)
	SUPPLEJACK (RFT) (1 / 1)	
	PIGEONWOOD (RFT) (4 / 4)	
Y = Number of independent (different bird and/or date) observations	CLEMATIS SP. (LEA) (1 / 1)	
	MAPAU (RFT) (1 / 1)	
	ASPLENIUM FL. (FR) (1 / 1)	
	INVERTEBRATES:	
	– slow flying (1 / 1)	
	– bagmoth (2 / 2)	

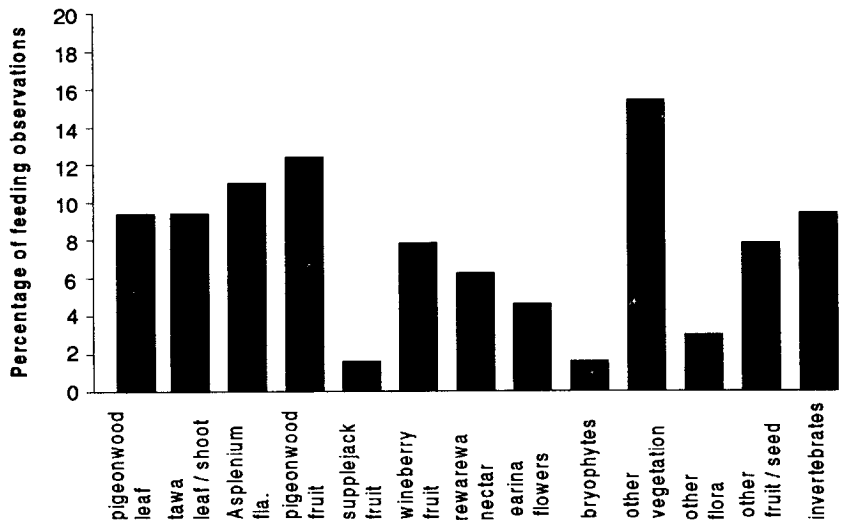

Figure 3 **Kokako food types at Mapara during November 1993 to March 1994 (n = 66).**

3.6.2 Nestling foods Usually it was difficult to observe foods as they were fed to nestlings. Larger food items could be recognised as they were carried to the nest or whilst being offered to nestlings. Other foods were identified from remains in droppings collected whilst banding the nestlings. Birds were not seen to transfer any leaf material to their young; insects and fruit made up all items of observed diet (Table 13). Last season some green material, presumed to be finely ground leaf, was seen being fed to nestlings at one nest.

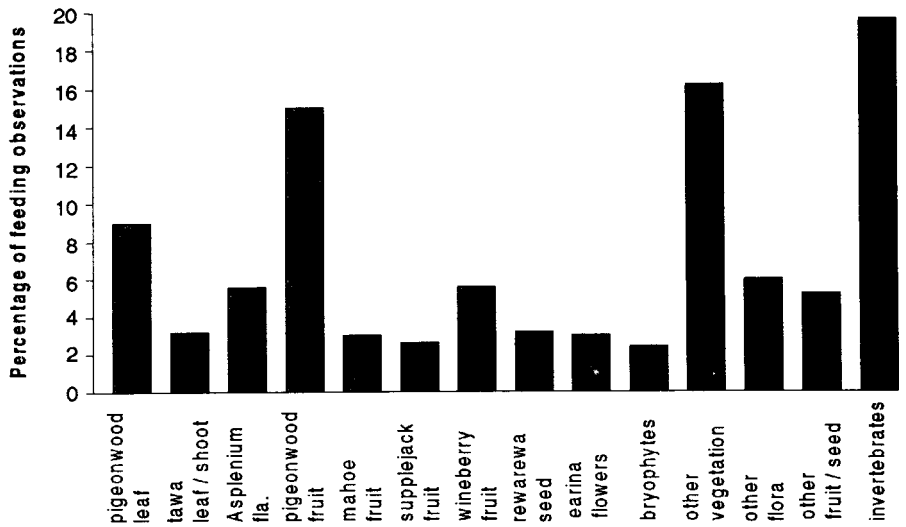

Figure 4 **Kokako food types at Mapara during the breeding season (Nov. to Mar.) 1991 to 1994 (n = 298).**

Table 13 Foods of nestling kokako.

Date	Nest	Food tore	Info. Source
20/12/93	Archimedes	Winged insects	Food pass
28/12/93	Zigzag	Fruits of karamu, pigeonwood, wineberry and astelia Manuka beetles. Small spider	Droppings
30/12/93	Crystalfire	Pigeonwood fruit Manuka beetle, tree wets, other insects	Droppings
30/12/93	Singleton	Fruits of pigeonwood, bush lawyer	Droppings
30/12/93	Eureka	Pigeonwood fruit	Adult's bill
3/1/94	Nice	Pigeonwood fruit	Adult's bill
2/2/94	Ezama	Fruits of pigeonwood, wineberry Manuka beetles, other beetles	Droppings
8/2/94	Ezama	Karamu fruit	Adult's bill

3.7 Moult

Kokako were mostly captured during spring and late summer so we do not have full records of the moult cycle. The onset of moult is usually around early February, but is later if birds are breeding. Loss of the central tail feathers is generally the first sign that moult has begun. During late March 1994 all three non-breeding birds captured were moulting heavily over their head and neck regions and new feathers were still growing in their tails and wings. Birds with scruffy body plumage have been noted as late as mid-April, but 20 kokako observed in late June were all evenly feathered.

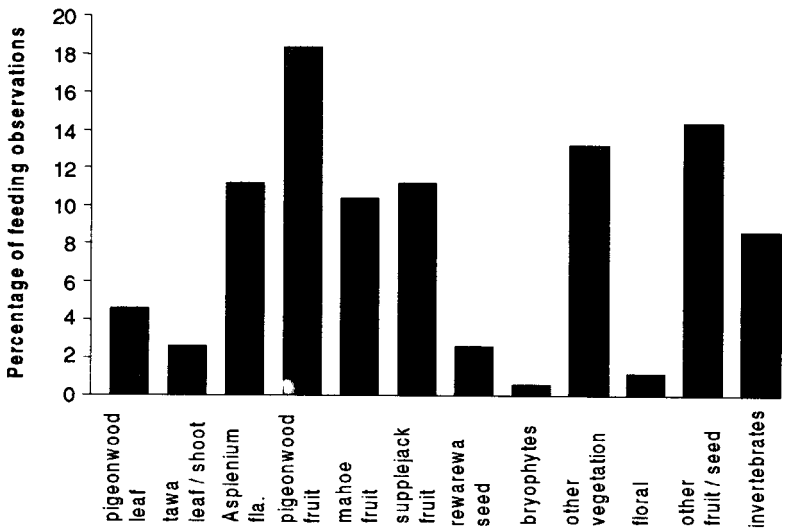

Figure 5 Kokako food types at Mapara outside the breeding months (Mar. to Nov.) 1991 to 1994 (n = 150).

4. DISCUSSION

4.1 Banding and measurements

Banding and the use of transmitters have not caused any adverse affects or observed behavioural changes in the kokako. Two birds are known to have lost all, or part of, a colour band but as yet this has not resulted in any unresolvable confusion of individual identities. The use of both bands and transmitters continues to provide useful information on the movements and general ecology of the species which will be crucial to its future management. With the banding of nestlings again this year we stand to gain further information on juvenile survival and recruitment to the breeding population; information which will help us to predict the long term viability of the Mapara population. Such results will also provide baseline information with which we can begin to model other populations of North Island kokako.

Both tarsometatarsus length and weight provide an indication of the sex of a bird. When used together we can predict the sex of a bird with 75% reliability. To date this is based on only 22 of the kokako measured, because sexing of each kokako has relied upon determining its role in incubation.

4.2 Population trends

Another small increase in the number of territorial adults and number of pairs, and good fledgling output give cause for continued optimism for the future of this population under the current management regime. The observed survival rate of 92% of fledglings at the end of their first year is high for a passerine: cf. 49% in English blackbirds (Simms 1978); 3 to 50% in yellowheads (Elliot 1990); 11 to 33% in riflemen (Sherley 1985). Fledgling survival is possibly enhanced by the 2-3 month post-fledging period of parental care as well as the predator-reduced environment.

Of pairs which attempted to breed, 67% raised young (cf. 80% last year). This year only one of three pairs which had failed nestings renested; this too failed. This year only 43% of pairs made any breeding attempt, compared to 58% of pairs last year. Possibly, breeding inexperience and late pairing of seven new pairs contributed to this. Five long-established pairs have not bred at all in the past three seasons. The reason for this lack of attempts remains unanswered, but may involve food availability, habitat quality, sex, age and/or other unknown factors influencing the birds.

To date we know of no female kokako having spent an entire season as a single. Seven kokako which have remained single for at least one breeding season, but have subsequently paired, have all proven to be males. We only know the sex of two of the four banded subadults which paired this season, both were female. The indication from these observations is that the sex ratio of the population is currently skewed, with an excess of male birds. The distribution of tarsometatarsus lengths suggest a ratio of 27 males to 18 females in the banded adult population (Fig. 6). Females may be under-represented in the population due to a hypothesised greater vulnerability to predation whilst incubating.

The unpaired portion of the population has reduced to 29%, from 34% last season. It is hoped that, as new individuals are recruited to replace and supplement existing pairs,

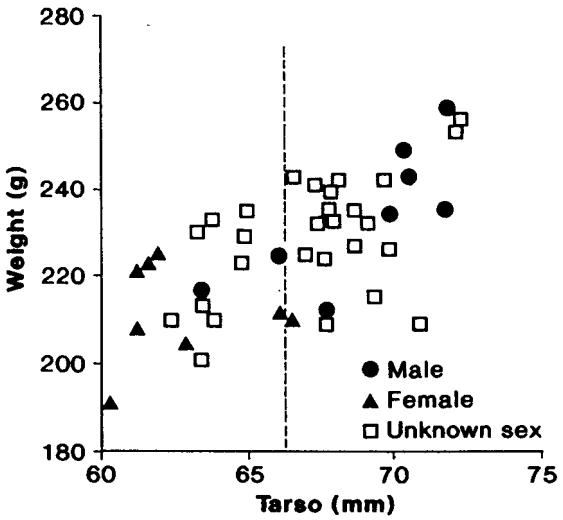

Figure 6 Tarsometatarsus versus weight of all kokako measured at Mapara.

we may observe a reduction in the proportion of non-productive pairs, and a continued reduction in the number of territorial single birds. As banded juveniles are recruited into the population we would expect to see a greater proportion of paired kokako in future years if this suggestion is correct. Assuming that the sex ratio of new recruits is equal, and the cause of differential mortality has been removed, it may still be at least a generation before the population consists of equal numbers of males and females.

Long-term monitoring of this kokako population and their major food plants may help to determine whether food availability plays a role in limiting breeding. Of particular interest will be to see whether currently non-breeding pairs do breed in a season of high fruit availability.

Kokako were generally thought to form stable pairs which remained together throughout successive years. Individual banding of the Mapara population has revealed that 42% of pairs changed mates in the past year and 33% did so in the previous year (see Table 7 above). Both sexes of kokako have been known to leave a partner to form new pairings elsewhere. Likewise, remaining mates of both sexes have held their territory and been joined by new incoming mates. We hope that with increasing numbers of banded birds in the population we may elucidate details of the social organisation of the Mapara population. Whether breeding success can be related to the territory, or is more an attribute of the individual birds may shed some light on the non-breeding subset of the paired population.

At present kokako utilise approximately 13.5% of the Mapara forest area. Without knowledge of the criteria by which territories are selected we cannot predict the likely carrying capacity of the reserve. Nevertheless we fully expect a continuation of the current kokako population increase to densities well in excess of the present 0.044 kokako per hectare.

4.3 Predation

The use of Brodifacoum anticoagulant poison presented in pollard baits from feeding hoppers resulted in a different pattern of mammalian kill to what had been previously achieved using aerial 1080 applications. Mammal monitoring this season indicated that rodent densities were similar to the 1992/93 season. Possum densities were lower than achieved last year. In addition low numbers of stoats caught in the three months following the start of poisoning and the discovery of a feral cat which had died of Brodifacoum poisoning suggest that secondary poisoning of non-target mammals may have been an important additional factor. No possum predation was recorded this season, but two of four nest failures were attributed to rat predation. Lack of breeding attempts again probably slowed the rate of population recovery to a greater extent than did predation.

It is not known to what extent trapping of potential mammalian predators near nests reduced predation levels of their contents over and above that provided by the poison bait stations. Around one nest, which was outside the reserve and hence not covered by the poison operation, 8 possums, 15 rats and a stoat were killed. Single possums were caught at only two kokako nests within the reserve in 1993/94 compared with an average of 4.5 possums at each nest last year. Ship rats were killed around all of this years nests.

4.4 Breeding

The onset of nesting was fairly synchronous with five attempts beginning in the same week. Timing of the first nesting (in late November) was very similar to that of the last two years. Only one of four pairs which lost first nest attempts renested, despite these losses being sufficiently early in the season to allow for re-nesting. All nesting was over by 20 February 1994 compared to last year when the last nestlings were fledged in late March. The timing of nesting again coincides with the ripening of the new season's pigeonwood fruit (although this year a small amount was still available of last season's crop). This year, however, pigeonwood fruit accounted for only 12% (cf. 18% last season) of the diet during the November to March period. Insect consumption was also less during the 1993/94 season at 9% of observations (cf.17% last year). The balance of the diet this season included a variety of other foods (see Table 12, and Fig. 3-5 above). A full analysis of the feeding and phenological data will be completed this year.

Kokako lay clutches of one, two, or three eggs. This year Ezama and Etombi laid a three-egg clutch but only one chick was present one month later, no sign was found of the other eggs. Either the parents or a predator had removed these from the nest. The average size of 17 successful broods in the past three years has been 1.9 chicks, including three broods of three siblings. Kokako thus have a moderate reproductive potential and are capable of a rapid population recovery if nest predation is minimised.

4.5 Nests

Several features of kokako nesting illustrate adaptations to avian as opposed to terrestrial based predators. Kokako nests were always best concealed from above and birds usually entered from below the canopy, regularly climbing to the nest from the ground. This may leave scent trails which mammalian predators, with their generally strong sense of smell, may be able to follow. The strong smell of the bird, and only

minimal efforts at removing chick faeces results in strong smelling nest sites. We could often smell nests from several metres distant and suggest that some predators, which hunt by scent, might do even better. The incubation period (~20 days) is long for a passerine and the total nesting period of 7-8 weeks gives ample opportunity for detection by predators.

5. RECOMMENDATIONS

It is recommended that this study be continued in its present form for two further seasons. Afterwards some level of kokako population monitoring is recommended to build on existing knowledge of important population parameters. Banding and subsequent monitoring of nestlings is particularly important as information on average juvenile mortality rates, and age of sexes at first breeding will greatly enhance the accuracy with which we can model kokako population changes as an aid to guiding future management of the species. Continuing the detailed study of nest fates throughout a five-year period of mammal control will lessen the likelihood of false conclusions regarding the impacts of such control on kokako.

It is hoped that continuation of both diet and phenological observations over a five-year time frame will show up any link with kokako breeding effort. This aspect of the work will be fully written up at the completion of the study.

Ecological information about the species, in particular juvenile survival, age at first breeding and mortality, will allow us to make better predictions about the future sustainability of this, and other, kokako populations and the levels of management intervention which may be required. Such information should continue to be collected whenever possible.

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