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PRELIMINARY RESULTS AND OBSERVATIONS ON NORTH ISLAND KOKAKO PRODUCTIVITY AND ECOLOGY AT MAPARA WILDLIFE RESERVE, KING COUNTRY, JULY 1992-JUNE 1993

by

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by
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ABSTRACT

These results are from the fourth 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 described.

The territorial kokako population of the reserve had increased slightly from 49 to 52 birds. The density of kokako at Mapara is now 0.04/ha of forest. Seventeen pairs were present during the November 1992 to March 1993 breeding season, although not all pairs remained together for the entire season. Ten pairs made fourteen breeding attempts. Four first attempts succeeded in raising nine chicks. Six first attempts failed, two due to predation by possums (*Trichosurus vulpecula*). Four kokako pairs re-nested, raising a total of 6 chicks. Observations on feeding and movements of kokako are included.

I. INTRODUCTION

This is a summary of information gathered about kokako during the period July 1992 to June 1993 at Mapara Wildlife Management Reserve. Previous reports by the same authors describe the previous three years work (Sherley *et al.* 1991, Flux *et al.* 1992). Background information on the mammal control work carried out at Mapara during this period is presented by Bradfield (1993).

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

2. METHODS

Each nesting attempt by kokako was studied to determine its fate. If nests were preyed on we hoped to identify which predators were involved. At Mapara introduced small mammals had been reduced in numbers by aerial application of 1080 pollard baits. Fenn traps spaced along ridge tracks throughout the reserve provided some level of year round mustelid and rat control. Deer were not present and goats and pigs were maintained at very low levels by shooting.

This year traps and Talon poison baits were set on the ground around all kokako nests found (Bradfield 1993). These provided additional protection against small mammal predation as the level of mammal reduction achieved by the 1080 aerial drop was not considered sufficient.

2.1 Bands and Transmitters

Adult kokako were caught using canopy rigged mist-nets. Kokako were leg-banded with both metal and individual colour combination bands for field identification. Radio transmitters weighed 7-10 g and were fitted, using backpack harnesses, to nine adult kokako as an aid in monitoring breeding. Harnesses were of light nylon cord with a weak link (Karl and Clout 1987). Breaking strain of weak links was approximately 750 g. Transmitters used were Sirtrack single stage units with expected lives of nine to twelve months. Eighteen nestlings were banded in their nests at 10 to 15 days of age, 2 of these were also fitted with radio-transmitters so as to record their movements once they became independent. Birds were weighed at the time of banding and adult tarsometatarsus length was recorded.

2.2 Survey and Monitoring

A census of territorial adults was carried out during six weeks up until 1 November 1992. All known territories were checked for occupancy and identity of kokako when banded. Areas of the reserve not previously occupied by kokako were surveyed using standard "walk through" technique (Rasch 1992); taped calls were played at approximate 250 m intervals along ridges.

From 1 November 1992 until 1 March 1993 all pair territories were visited weekly. Kokako fitted with radio transmitters were followed using portable receivers. Birds without transmitters were usually located during their dawn song period 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 also watched weekly to ensure adults were in attendance. Behaviour of adults at nests and 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.

Observations of feeding were recorded only when food was clearly identified. Kokako spend much time in epiphytes and high-canopy where they and their foods were rarely identifiable. Movements, both of territorial adults within usual ranges, and of greater distances were mapped whenever possible.

3. RESULTS

3.1 Banding

Nineteen adult kokako were mist-netted, 4 were recaptures of previously banded birds. Eighteen nestlings were also banded though only 12 of these fledged. Five chicks from 2 broods were eaten by possums at about 15-20 days of age, the third chick from one of these broods was captive reared after falling from its nest. A total of 44 adult kokako and 19 juveniles have now been banded at Mapara (Tables 2-4).

Juvenile's legs are large enough to band at less than 10 days of age. Within broods obvious size differences between chicks probably reflect order of hatching though asynchronous hatching has never been confirmed for this species (Table 4). At one nest (Old Holborn) we had to delay banding of the youngest member even though both its siblings had sufficiently large legs.

3.1.1 Measurements Measurements taken are presented below (Tables 2-4). Sex, where recorded, is judged from nesting role,(incubation is the exclusive role of the female, as has been confirmed by observations of nesting in captive kokako, P Moreton pers. comm.).

Mean weight of 44 adult kokako was 229 g, (s = 17, range 191-275 g)
Mean weight of 13 male kokako was 229 g, (s = 12, range 209-254 g)
Mean weight of 7 female kokako was 211 g, (s = 12, range 191-225 g)
Mean tarsometatarsus length of 11 male kokako was 67.28 mm, (s = 2.12, range 63.50-70.85 mm).
Mean tarsometatarsus length of 6 female kokako was 62.69 mm, (s = 2.07, range 60.20-66.25 mm)

Thus the measurements of 3 of the 13 males fell within the observed female range and similarly 1 of 6 females lay within the male range.

Most chick weights were recorded only at the time of banding (Table 4). In most nests small differences in weights of siblings were observed. In the first Old Holborn nest, the difference between the smallest and largest of three chicks was 51 grams. This nest and two others were visited twice; weight gains of chicks are given in Table 1.

Table 1 Weight gain of kokako nestlings.

Identity		First measuring		Second measuring		Growth rate
Chick	(Parent)					(g/day)
Rizla	(Old Holborn)	12/1/93	118 g	18/1/93	167 g	8.2
Rolli	(Old Holborn)	12/1/93	100 g	18/1/93	145 g	7.5
Runt	(Old Holborn)	12/1/93	67 g	18/1/93	90 g	3.8
Opiki	(Singleton)	21/1/93	125 g	30/1/93	168 g	4.8
Punk	(Crystalfire)	4/2/93	137 g	13/2/93	154 g	1.5

We did not gain accurate information on age of nestlings when weighed so cannot describe the pattern of weight increase. These results, nevertheless, suggest considerable variation in growth rates both within and between broods.

3.2 Transmitters

Transmitters were fitted to nine adults and two juveniles (Tables 3 and 4). Immediately after release most kokako pecked at their bands and transmitters. Subsequently birds apparently ignored the devices, no difference was observed in behaviour of marked and unmarked birds within a pair. Some of these transmitters have been subsequently recovered when recapturing kokako, others either remain on the birds or have been shed by weak link failure.

Despite many technical failures, transmitters were thought to be worthwhile. Use of radio telemetry meant a single observer could monitor several kokako pairs each day as tracking was no longer limited by when the birds were singing.

Table 2 Mapara banded kokako (to March 1992).

Date	Name	Left	Right	Age (sex)	Weight	Tarso.	Tx.	Grid ref*
29/6/79	Skeptic	E130748	W/G	Adult	259	71.8		
11/4/90	Nerak	R	E177101/R	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	Morning glory	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

* Grid references from NZMS 260 map S17
Date = date on which bird was banded
E123456 = metal band number
Colour bands = red (R), white (W), yellow (Y), blue (B), green (G)
Tarso. = tarsometatarsus length
Tx. = frequency of radio transmitter

Table 3 Kokako captured during spring 1992.

Date	Name	Left	Right	Age	Weight (g)	Tarsomet. (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	E177128	Adult	227	68.65	40	093 909	M?
19/9/92	Pinkdot	GB	E177129	<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	B/E177131	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/E177132	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	RB	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

* Indicates previously banded birds recaptured this season.

Note: Duja had one irregular leg (possibly broken early in life ?) measuring 68.65 mm

Table 4 Nestlings banded' at Mapara, during the 1992/93 season.

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	RB	136	099 904		N
4/1/93	Manga	Noddy	B/E177145	GB	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 Holborn	Rizla	G/Y	G/E177051	118	086 898		N
12/1/93	Old Holborn	Rolli	RB	G/E177052	100	086 898		N
18/1/93	Old Holborn	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	GB	148	097 904		Y
3/3/93	Old Holborn	Vulpec	G/E177060	R/W	127	097 898		Y
3/3/93	Old Holborn	Trichos	G/E177061	B/Y	110	097 898		Y

* Chicks were banded and weighed at ten to fifteen days.

† Punk and Collos were both sexed by nesting role during the 1993/94 season.

Note: The weight of Runt on 12/1/93 was 67 g.

located. Their previous range was poorly known, but was probably subsequently divided between two adjoining pairs.

Rumple (banded) left its previous partner (Stiltskin) around 31 October 1992 and joined a neighbour (Matabeelee), 500 m to the northwest, who had lost its previous partner (Mystar-e) on about this date.

Morning Glory, a male, maintained its previous range as a single whilst ex-partner Batagooli, a female, formed a new pair with an unbanded bird over 1 km away.

Table 6 Mapara kokako contact times (in minutes) during the 1992/93 season.

Week ending	7/11/92	14/11/92	21/11/92	28/11/92	5/12/92	12/12/92	19/12/92	26/12/92	2/1/93	9/1/93
Archie & Angel	P 17m	P 65m	P 30m	P 23m+		P 64m	P Slm	P 45m	P 60m	P 35m
Crystaf. & Marama	P 40m	P 61m	build	nest	nest	nest	nest	failed	P 43m	nest
Nice & Sleazy	P 38m	P 76m	build	nest	nest	nest	chicks	chicks	chicks3	fail
Tui & Hemi	P 60m	P 50m	P 42m	P 48m		nest	nest	fail	P 43m	S 75m
Swivel. & Manga	P 50m	P 56m	build	build		nest	nest	chicks	chicks	chicks
Gian & Duja	P 60m	P 65m	P 60m	P 16m	P 37m	P 60m		P 42m		p 46m
Skrill & Skathe	P 35m	P 57m	P 60m	P 46m	P 25m	P 64m	S67/nest	nest?	nest?	nest?
Old Hol. & Zigzag	P 90m	P 52m	P 53m	P 44m		P 52m	P 60m	P? 30m	P? 40m	nest
Ulf & Elc		P 45m	S 1lm				P 4m!			
Rumpltu & Stilt.	P 63m	P 32m	P 90m	P61m		P 48m	P 12m		P 42m	P 93m
Eureka & Archim.	P 36m	P 45m	P 145m	P 54m		nest	nest	chicks	chicks	chicks
Bambooz. & Bosnia	P 24m	P 37m	P 122m	P 74m	P 36m	P 45m	P 51m	P 141m	P 49m	P 20m
Asim. & Kalim.	P 18m	P 45m	P 90m	P 38m	P 5m	P 57m	P 43m	P 60m	P 62m	P 40m
Rumple & Matabee.	P 30m	P 45m	S 100m	P 10m		P 64m	P 60m		P 54m	P 37m
Batagooli & Etak				nest?		P 53m	P 25m		P 60m	P100/S40m
Singleton & Solit.		P 67m	P 67m	build	build	nest	fail	P 62m	nest	nest
Ezama & Citsat	P 25m	P 55m	P 80m	P 36m	P 55m	P 80m	P 80m		P 62m	nest

Week ending	16/1/93	23/1/93	30/1/93	6/2/93	13/2/93	20/2/93	27/2/93	6/3/93	13/3/93
Archie & Angel	P 71m	P 156m	P 100m	P 62m	P 57m		P 53m		
Crystaf. & Marama	nest	nest	nest	nest	chick	chick	chick	fledge	
Nice & Sleazy	P 5m	P 62m	P 80m	S 93m	nest	nest	nest	chicks	chicks
Tui & Hemi	S 79m	S 89m	S 40m	S 93m					
Swivel. & Manga	chicks	fledge							
Gian & Duja	P 35m	P 4_5m	P 5m	P 27m		P? 55m	P 49m	P 22m	
Skrill & Skathe		S 75m	S 55m	S 69m	S45	S 57m	S 57m	S 60m	fledge?
Old Hol. & Zigzag	chicks	fail	P 25m	S 180m	nest	nest	nest	chicks	chicks
Ulf & Elc					P 25m				P 103m
Rumpltu & Stilt.	P 30m	P 40m	P 55m	P 54m		P 54m	P 35m		
Eureka & Archim.	chicks	chicks	fledge						
Bambooz. & Bosnia	P 65m	P 36m	P 46m	P 40m		P 37m	P 49m		
Asim. & Kalim.	P 71m	P 40m	P 77m	P 44m	P 45m	P 45m	P 33m	P 40m	
Rumple & Matabee.	P34/S36m	S 76m	P+ 93m	P 54m	P 63m		P 39m		
Batagooli & Etak		S 240m		P+ 60m	S 37m				
Singleton & Solit.	nest	chick	chick	chick	chick	fledge			
Ezama & Citsat	nest	nest	nest	chicks	chicks	chicks	fledge		

P = pair S = single

Of nine transmitters fitted to adults three failed within three months, one vanished with the bird and one was shed due to weak link breakage, probably after entanglement. The remaining four transmitters remained operational throughout the season.

3.3 Population monitoring

3.3.1 Census of territorial adults On 1 November 1992 we knew of 16 pairs and 14 single kokako, holding territories at Mapara (see Table 5 for comparison with previous years). Note that these counts do not include non territorial adults or sub-adults. Thirteen of these pairs remained together throughout the season. One pair was last seen on 28/10/92 and one new pair was formed on about this date. The two remaining pairs present on 1/11/92 had split by mid January.

Table 5 Mapara kokako population and breeding, October 1989 to March 1993.

	31 Oct '89	Nov '89 to Mar '90	31 Oct '90	Nov '90 to Mar '91	31 Oct '91	Nov '91 to Mar '92	31 Oct '92	Nov '92 to Mar '93
Total pairs	16	16	17	16	15	16	16	17
Total single	20	20	17	16	19	15	14	18
Pairs nesting						6?		10
Total nests						6?		14
Nests succeed						3		8
Total fledging		0?		5 to 7		7		15
Territorial adults	52	52	51	48	49	47	49	52

Between 11 December 1992 and 6 February 1993 one further pair was present, thus bringing the total to 17 pairs and 18 single territorial kokako within the reserve.

3.3.2 Monitoring kokako pairs The times each pair were followed for each week are presented in Table 6. Gaps in the table are the result of bad weather, or in some cases our inability to locate a pair within their regular range.

3.3.3 Pair composition changes Several changes have occurred in the kokako pairs since last breeding season. Of the sixteen pair territories occupied during the 1991/92 season, ten continued to occupy the same areas this season. Ten birds belonging to these 10 territories were banded (both birds of 4 pairs and 2 members of different pairs) so we could by and large confirm the occupants remained the same.

Cuckoo and Stinky (both banded) had been replaced by two unbanded birds, but their range remained as for the previous occupants. Cuckoo was never re-sighted, but Stinky remained in occupation of a range 300 m to the east.

Marzba and Moro (both banded) had both disappeared and a single (Turnpike) had replaced them in their previous range.

Doublevision pair (unbanded) was present on 31 October 1992, but was not subsequently

Three new pairs were present, one occupying a previously unoccupied area (both unbanded) and the other two comprising singles (one a banded male) gaining unmarked mates but retaining their original ranges.

Birds which are no longer present in their previous ranges cannot be automatically considered dead. It is known that some previous territory holders remain alive, but no longer defend territories and are inconspicuous because they do not sing. Only when a bird has remained unseen for a year do we consider it dead. Mortality rates will be more fully covered in next season's report, however, of the 40 adults banded to the end of 1992 we know of only 5 which are dead and 2 (Cuckoo and Mystar-e) which are probably dead (i.e., have not been seen for almost 12 months). This represents a mortality rate of 8.9% over 62 adult "banded bird years", to June 1993.

3.3.4 Kokako ranges Areas of kokako ranges were calculated by drawing minimum area polygons (Figure 1) to include all points at which identified pairs were observed during October 1992 to March 1993. Kokako ranges thus derived varied from 2.8 ha to 11.6 ha (Table 7) with the average area being 5.9 ha (n = 17, s = 2.5). Kokako pairs were generally found within a smaller (and predictable) core range of about 3 ha (Table 7) from which occasional forays were made. When birds did make forays beyond their usual core range this was never into the core range of other kokako. Only in one instance did the territories of two pairs (mapped by minimal area polygons)

Table 7 Range size of kokako pairs.

Pair name		Total no. of obs.	Total obs. time (mins)	Range area (ha)	No. of obs. outside core range†	% of time outside core range†
Eureka & Archimedes	#*	16	1010	8.4	4	31
Manga & Swiveltrout	#	14	825	5.4	1	7
Bamboozled & Bosnia	*	23	688	6.9	6	37
Gian & Duja	*	16	634	7.7	2	6
Crystalfire & Marama	#*	19	1861	2.8	1	1
Asim. & Kalim.		18	841	3.1	2	4
Old Holborn & Zigzig	#	22	1147	3.6	4	8
Singleton & Solitaire	#	17	1298	7.4	4	14
Ezama & Citsat	#	20	1176	3.6	3	5
Skeptik & Skathe	#?*	18	1224	6.6	6	19
Tui & Hemi	#	13	1008	4.2	3	9
Rumple & Matabeelee		17	899	5.3	5	19
Archie & Angel		16	990	3.2	4	16
Nice & Sleazy	#*	30	2137	7.1	5	9
Rumpltu & Stiltskin	*	22	1266	9.4	13	44
Batagoolie & Etak	#?	10	705	4.1	4	11
Ulf & Elc		8	265	11.6	4	54

* Denotes kokako fitted with a transmitter.

\# Denotes pairs which bred during the season.

† Core range calculations were made by superimposing a circle of 97.7 m diameter (3 ha) over the mapped movements of the kokako. This circle was placed so as to encompass the area with most observations. Birds fitted with radio transmitters were followed at all times of the day whereas others were followed mostly in the morning.

slightly overlap. Nesting birds appeared to concentrate their feeding in areas close to the nests. Where nests were present, observers spent most time recording activity at the nest. Radio tagged birds were followed away from their nests on a few occasions, but none ventured far from the nest site. Consequently, birds which failed in their first nesting attempts and re-nested had little opportunity to venture far afield during the period of our observations. It is apparent however that even non-breeding territorial kokako pairs are generally found within a core range of approximately 3 ha.

Overall, Mapara has 1350 ha of forest habitat; pair ranges occupy about 100 ha, and singles (estimated at 5.9 ha/bird) occupy 106 ha. Thus kokako ranges account for only about 206 ha, 15% of the forest area. Perhaps not all forest area is suitable kokako habitat. Currently all Mapara kokako ranges are centred about prominent ridges. There were 0.01 pairs per hectare, and a total of 0.04 kokako per hectare.

Few obvious territorial disputes were observed. Five interactions between neighbours were recorded, two involved singing and occasional chasing, the other involved fighting between three or more birds. In this latter encounter the fighting birds fell to the ground whilst locked in combat.

One non-territorial sub-adult kokako was radio-tagged and regularly monitored. Its movements covered much of the south and central blocks of the reserve. This bird was extremely mobile, on one occasion covering over 2 km in 4 hours between radio fixes.

3.4 Breeding

3.4.1 Location of nests Nests were located either during the building stage or during incubation. Nest building was a very obvious activity, in at least some cases this occupied three or more days. Large quantities of plant material are carried by the female directly to the nest site. At this stage the male of the pair was usually close by and regularly interacted with its mate.

Incubation is carried out by the female only, as has been determined from observations of the banded breeding pair at the Mount Bruce National Wildlife Centre (P Moreton pers. comm.). Lengthy follows of the male alone usually signify the onset of incubation. Females leave their nests briefly to feed usually at least once in a two hour period. 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 repeat visits by the male to a certain tree, or sightings of the female which lead to the discovery of a nest.

3.4.2 Nesting attempts Ten of the pairs of kokako made 14 nesting attempts (Tables 8 and 9). Four of these were re-nests after the loss of a previous nest. In the case of Tui it is uncertain whether the nest was ever laid in. Neither Batagooli nor Skrill nests were located but were assumed to exist from the behaviour of the parents; both are included in Tables 8 and 9. It is possible that Batagooli made two nest attempts, both of which failed at very early stages. Skrill exhibited nesting behaviour throughout the assumed nesting period, but their nesting area prevented us from locating the site. In this case 3 unbanded fledglings seen on 19 March 1993 are assumed to have been produced from this nest.

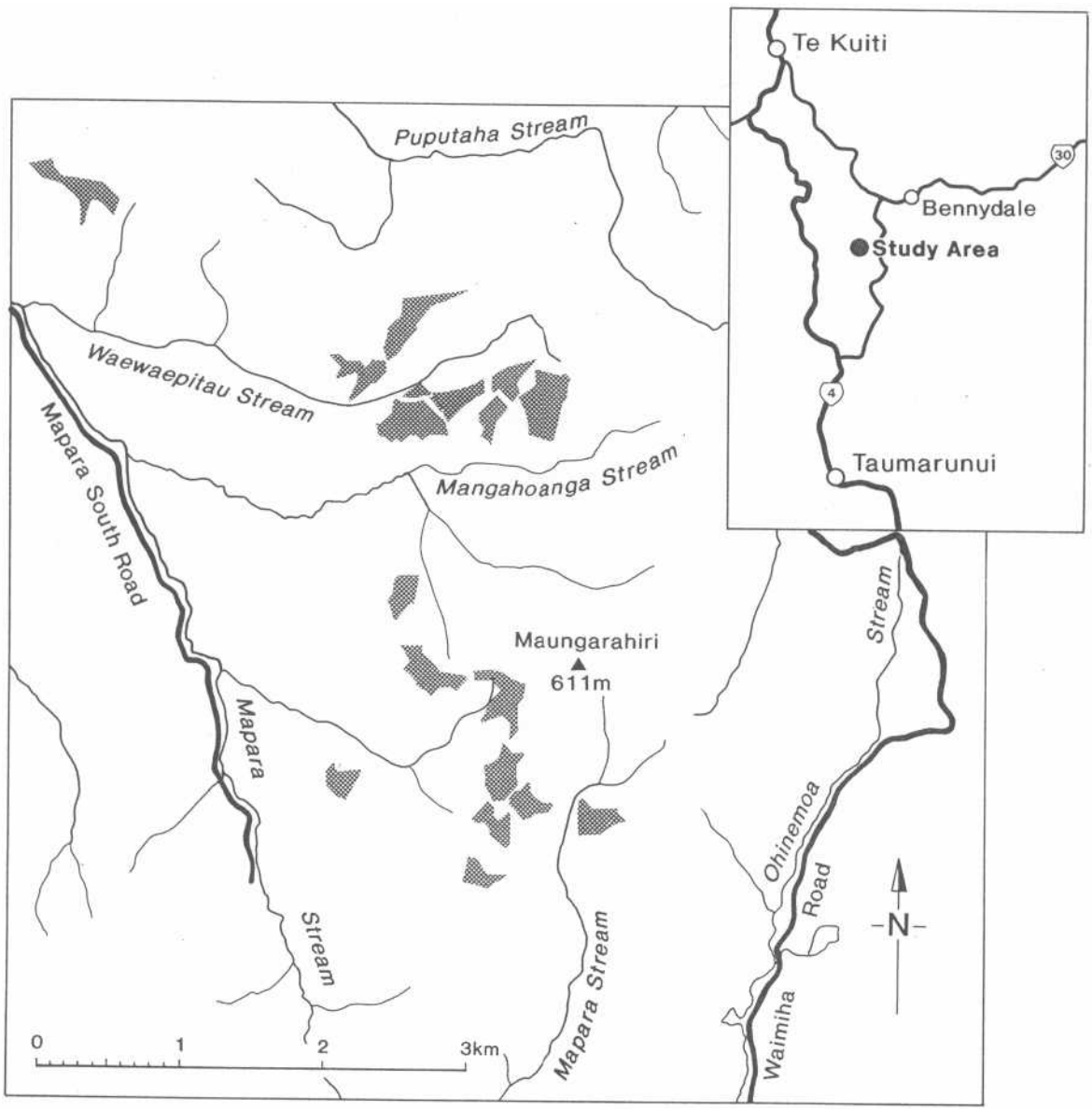

Figure 1 The ranges of kokako pairs in the Mapara Wildlife Management Reserve during the period November 1992 to April 1993.

3.4.3 Fate of nests A nesting attempt was recorded when a bird was known to be incubating or where known pairs exhibited typical nesting behaviour although the nests themselves could not be located. Eight of the 14 attempts (57%) succeeded in producing 15 fledglings (Table 8) in brood sizes of from one to three. Two of these fledglings probably would not have survived were it not for our intervention. Three chicks from the Eureka nest were found on the ground at about 10 days of age, one was dead and the other two were replaced in the nest.

Of the 6 attempts (43%) that failed, 2 were preyed on by possums at the young (8-15 days) nestling stage and one by rats during early incubation. At the remaining 3 nests the cause of failure could not be determined. In the Nice nest, 3 chicks were present when banded on 29 December. One chick fell from the nest shortly after banding and was successfully reared in captivity. The remaining two chicks were preyed on by a possum, within 4 days of banding. The nest bowl was torn up and mixed with feathers and remains of the two chicks. Both chick bodies were outside the bowl, leg bones and the skull of one were crushed and chewed. Plastic leg bands were broken and two bands showed clear tooth impressions. A crescent shaped chew of compacted feathers was found mixed with possum droppings amongst the nest material.

Three nestlings at Old Holborn nest were preyed on by a possum on 19 January 1993, one day after banding. Very little of the chicks was eaten, one had lost its upper mandible and had a broken tibia and wing, another had its left foot eaten and a large hole in the abdomen, whilst the third had its rump eaten and intestine pulled out. Again plastic bands were crushed and bore obvious tooth marks.

Table 8 Outcome of nesting attempts at Mapara, 1992/93.

Parent	Date found	Fate
Crystalfire	17/11/92	Fails in week 5. No sign, cause unknown, re-nests
Nice	18/11/92	Fails in week 7. One chick fell from nest 29/12, two chicks preyed on by possum, re-nests
Manga	18/11/92	Two chicks fledge by 20/1/93
Singleton	27/11/92	Fails in week 2. Two or more eggs eaten by rat,droppings in nest, re-nests
Batagooli	27/11/92	Fail?? Nest not located before failure.
Eureka	7/12/92	Three chicks on ground 4/1/93, one dead, two replaced in nest. Two fledge by 27/1/93
Tui	9/12/92	Fails in week 1. No sign , cause unknown. Pair splits
Skrill	16/12/92	Nest never located but assumed to have fledged three chicks seen nearby on 19/3/93
Singleton 2	29/12/92	One infertile egg in nest, one chick fledged by 17/2/93
Old Holborn	30/12/92	Fails in week 5. Three chicks preyed on by possum, re-nests
Crystalfire 2	4/1/93	One chick fledged by 1/3/93
Ezama	7/ 1/92	Two chicks fledged by 24/2/93
Nice 2	3/2/93	Two chicks in nest 18/3/93, both fledged successfully
Old Holborn 2	3/2/93	Two chicks in nest 23/3/93, both fledged successfully

Singleton nest failed by 16 December 1992, after a little over one week's incubation. Shell from probably two eggs was found, still wet with fresh albumen. Larger shell fragments had chewed margins. Rat droppings were found in nest bowl and rim. Shell fragments and albumen mixed through nest lining. This is very likely to be a rat predation though scavenging by rats following some other disturbance cannot be discounted.

Crystalfire nest failed between 14 and 21 December 1992. The nest bowl was undisturbed, three tiny egg shell fragments suggested that egg(s) had hatched before predation.

Similarly at Tui nest there were no clues. The nest bowl was clean and undisturbed. Although a bird had been sitting for at least part of a day we do not know whether an egg was laid before the nest was abandoned.

Batagooli nest was never located so status and cause of failure remain unknown.

All re-nests were successful, thus of the 10 pairs which made any breeding attempt, 80% were ultimately successful.

3.4.4 Nest descriptions Nest height varied from 5 to 35 m with a mean height of 15 m (n = 12, s = 9). Host tree species included 4 nests in tawa (*Bedschmiedia tawa*), 3 in mahoe (*Melicytus ramiflora*) and one nest in each of; pigeonwood (*Hedycarya arborea*), kamahi (*Weinmannia racemosa*), rimu (*Dacrydium cupressinum*), totara (*Podocarpus totara*) and hinau (*Elaeocarpus dentatus*).

No pattern was observed in choice of nesting sites. No birds reused nest sites from previous years though two pairs built nests within 50 m of their last years nests. Nests

Table 9 Calendar of nesting events for Mapara kokako, 1992/1993.

Week ending	21	28	5	12	19	26	2	9	16	23	30	6	13	20	27	6	13	20	27
	November			December				January				February				March			
Parent																			
Nice	B	I	I	I	C	C	3C	L				I	I	I	C?	2C	2C	2C	2F
Crystalfire	B	I	I	I	I	L		I	I	I	I	C?	1C	1C	1C	1F			
Manga	B	B		I	I	C?	C	C	2C	2F									
Eureka				I	I	C?	C	3C	2C	2C	2F								
Old Holborn						I?	I?	I	3C	L		I	I	I	C?	2C	2C	2C	2F
Tui				B	?	L													
Skrill					I?	I?	I?	C?	C?	C?	?	?	?	?	?	?	?	?	3F
Batagooli		I?		L?	I?		L												
Singleton		B	B	I	L		I	I	I	1C	1C	1C	1C	1F					
Ezama								I	I	I	I?	2C	2C	2C	2F				

B = building I = incubating C = chicks present L = nest lost/preyed on F = fledged

were built on ridges, slopes, and valley bottoms with many different aspects. Nests were often (8 of 12 nests) concealed amidst dense epiphyte or liane vegetation, usually asteliads (*Astelia* spp, *Collospermum* spp.), supplejack (*Ripogonum scandens*) or climbing rata (*Metrosideros* spp.). Others were generally well concealed by the host tree foliage. Ten of the 12 nests described had cover above estimated as 70% or greater, one had moderate cover (± 50%) and the other was quite open above (under 30% cover). This latter nest was the first nest attempt of Singleton and Solitaire, a newly formed pair. Lateral cover was moderate to dense in all cases, but from below 5 of the 12 nests had sparse cover only.

External nest diameters ranged between 15 cm and 40 cm. The small 15 cm by 10 cm nest of Citsat and Ezama was quite atypical in construction. Eight of the 12 nests consisted of a base platform of sticks (usually sourced from the host tree) and mosses/liverworts. The other four nests were hollowed into the bases of asteliad clumps and used no, or few, twigs. In all nests the bowl was lined with fine plant material, this included moss/lichen/liverwort (all nests), asteliad/grass leaf fibres (4 of 8 nests closely examined), *Cyathea* spp. tree-fern scales (4 of 8 nests). The nest bowl is generally quite deep (~8 cm) and about 15 cm in diameter. The small nest (10 cm by 15 cm) of Ezama was atypical in that most of the lining comprised a flattened chaffinch nest, supplemented with a small amount of asteliad leaf, lichen, and moss.

3.4.5 Behaviour at nests Only female kokako were involved in the building and incubation of nests. During the first three weeks of incubation females remained on their nests for periods ranging from 6 to 110 minutes (mean = 51 mins., s = 23, n = 14 observations). Absences of females from nests during this period were from 2 to 27 minutes (mean = 11 mins., s = 8, n = 19 observations). During this same period males visited nests every 2 to 82 minutes (mean = 34 mins., s = 21, n = 24 observations).

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 now 20 minutes (s = 11, n = 32 observations). Females were very irregular in the times they spent on nests brooding nestlings (mean = 19 mins., s = 15, n = 7 observations) and were absent from their nests for a mean of 20 minutes (s = 14, n = 24 observations).

Late in the nesting period both parents showed nearly equal activity at the nest. Most pairs now foraged together and returned as a pair to feed chicks (mean time for males foraging away from the nest = 21 minutes, s = 15, n = 34 and for females = 24 mins., s = 15, n = 21 observations).

In three nests parents were seen to remove chick faeces from the bowl or nest rim, both sexes were seen to perform this task. Kokako do not, however, consistently maintain clean nests; several nests were heavily soiled by chicks even by week 5 of nesting. By this stage observers could often smell the nests from up to 10 m distance!

Adults regularly approach nests on the ground and then "squirrel" up to the nest itself. This behaviour was observed at all except the Swiveltrout nest, despite the fact that one nest was 35 m up.

We could 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 seven nests:

Crystalfire	56 to 66 days	
Nice	48 to 54 days	
Swiveltrout	49 to 57 days	chicks hatch at 20 to 26 days
Old Holborn	51 to 57 days	
Eureka	46 to 63 days	chicks hatch at 16 to 29 days
Singleton	45 to 57 days	chicks hatch at 19 to 25 days
Ezama	43 to 54 days	

There was at least a week's difference in the nestling period between different nests. During their last week to ten days in the nest chicks spent much time stretching and flapping. Fledging was often accomplished over several days with chicks at first making short forays but returning regularly to the nest.

3.4.6 Movement of post-fledging juveniles For at least one month following fledging juveniles remained with their parents and were fed by them. During this period juveniles were seen to experiment with a variety of foods (and non-foods) and were to a greater or lesser extent feeding themselves toward the end of this first month. The following notes were recorded on individual birds:

- **Punk** was pecked by its female parent throughout rearing to the extent that it was totally bald on head and neck. This juvenile left its natal range within little more than one month of fledging. This bird moved immediately to an area about 1500 m away.
- One chick from the Swiveltrout nest (which fledged by 23 January 1993) remained with its parents for two months and then moved about 1500 m. The sibling from this nest remained in its natal range until October 1993.
- **Opiki** remained within its natal range until August 1993 when it left to pair with a single bird 500 m away.
- The two fledglings from the Eureka nest had left their parents within 43 days of fledging.

We do not have information on other fledglings other than that they were all with parents one month after fledging, but had left by September 1993.

3.4.7 Juvenile kokako characteristics Few nestlings have been seen before they reach 10-15 days. Three chicks under 10 days which we have seen have been near-naked with sparse down in obvious tracts. At this age the wattles are very small, concave and wrinkled structures of pale pink colour. Down and feather tracts of kokako nestlings are described by Gill (1993). When banded at 10-15 days the chicks are well covered in down and with tail rectrices and primaries beginning to elongate. The down plumage is generally a dull grey with developing feathering being considerably darker. Wattles at this age are still concave and wrinkled but are now blotched with lilac/purple veins especially about their margins. At fledging the tails are about three-quarters adult length and most down has been replaced by contour plumage. Tails appear to have reached full adult size within two to three weeks of fledging. Fledgling plumage is noticeably browner than that of adults, especially on the bird's flanks and back. Wattles

now appear a more even pink colour and remain this colour for at least three months. At seven months the wattles of one chick had become a purple/lilac colour and were still obviously smaller than those of an adult. A sub adult of about 10 months of age still had remnants of pink in otherwise blue wattles of near-adult size. Its plumage was still olive-brown tinged and its foot-pads were found to be soft and pale yellow in colour (adults are generally darker in the foot pad). Scales on the upper surfaces of the foot were notably smooth and soft and delicate in contrast to adults which appear more dull and "weathered", and often carry scars.

The calls of juveniles are quite distinctive; squeaky or warbled mews and broken, squeaky renditions of adult song. One year after fledging many sub-adults can still be discerned by their calls. During the first week after fledging most chicks are quite inactive and roost inconspicuously whilst awaiting feeding. By two weeks after fledging juveniles follow parents quite closely and have bouts of frenetic activity; running, chasing and flapping energetically though often clumsily.

3.5 Feeding

Observations of feeding were recorded during follows when the food consumed was clearly seen. Observations are, therefore, biased toward open, low growing species such as shrub-hardwoods. Kokako spent much time amongst epiphytes and high canopy 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 usually we have only recorded large insect prey species which the birds could not swallow intact. To date we have little knowledge of the nutritional value of kokako foods so interpretation of feeding observations is problematical.

Food types eaten are summarised into two-monthly periods for all feeding observations recorded during 1991 and 1992 (Table 10). This year we collected little feeding data during the winter months. During early spring the diet consisted largely of leaves and fronds. Supplejack (*Ripogonum scandens*) bears fruit throughout the year but does not seem highly sought after; these were only consumed when no other fruit was available in early spring. It can be seen that throughout its period of availability the fruit of pigeonwood (*Hedycarya arborea*) is highly sought after. The late ripening of pigeonwood fruit last year and possible consequent lack of high carbohydrate foods in spring may have contributed to generally later nesting. Several foods important to the birds last year were not available this season, notably mapau (*Myrsine australis*), rewarewa (*Knightia excelsa*) and passionflower (*Passiflora tetrandra*) fruits.

Table 10 Food types recorded for kokako during 1992 and 1993.

January/February		March/April		September/October	
PIGEONWOOD (LEA)	(2/2)	MAHOE (LEA)	(1/1)	PUKA (nLEA)	(1/1)
(RFT)	(12/11)	(FLW)	(1/1)	PIGEONWOOD (LEA)	(1/1)
(UFT)	(1/1)	PASSIONFLOWER (yLEA)	(1/1)	MAHOE (LEA)	(1/1)
WINEBERRY (RFT)	(4/4)	TAWA (LEA)	(1/1)	(mLEA)	(1/1)
SUPPLEJACK (RFT)	(1/1)	PIGEONWOOD (RFT)	(11/8)	SUPPLEJACK (RFT)	(3/3)
CLEMATIS SP. (LEA)	(1/1)	KANONO (RFT)	(3/3)	(nLEA)	(1/1)
KANONO (RFT)	(1/1)	RIMU (cones, female)	(5/3)	ASPLENIUM POLY. (FR)	(1/1)
KARAMU (LEA)	(1/1)	(shoot or male cone)	(1/1)	ASPLENIUM FLAC. (FR)	(7/6)
HINAU (UFT)	(1/1)	DENDROBIUM CUN. (nLEA)	(1/1)		
(RFT)	(1/1)	PUKA (nLEA)	(1/1)		
RIMU (cones, male)	(2/2)	HINAU (RFT)	(1/1)		
(LEA)	(1/1)	INVERTEBRATES:			
EARINA AUT. (FLW)	(1/1)	– Scale insect	(1/1)	**November/December**	
MOSS CAPSULES	(2/2)			MAHOE (mLEA)	(2/2)
INVERTEBRATES:				(nLEA)	(2/1)
– Green chafer	(1/1)			HINAU (FLW)	(1/1)
– Caterpillar	(3/3)			KANONO (nLEA)	(2/2)
– Spider web	(1/1)			(LEA)	(1/1)
– Bagmoth	(1/1)			HANGEHANGE (FLW)	(1/1)
– Beetle	(1/1)			REWAREWA (FLW)	(1/1)
– Unid. insects	(1/1)			KAMAHI (FLW)	(1/1)
– Scale insects	(5/4)			TAWA (LEA)	(1/1)
				SUPPLEJACK (nLEA)	(1/1)
				(LEA)	(2/1)
				(RFT)	(4/3)
				PIGEONWOOD (LEA)	(9/7)
				(nLEA)	(5/5)
				(RFT)	(8/8)
				RIMU (nLEA)	(1/1)
				RUBUS CIS. (RFT)	(1/1)
				EARINA Sp (FLW)	(3/3)
				(stem base)	(1/1)
				DENDROBIUM CUN. (LEA)	(1/1)
				PUKA (LEA)	(3/3)
				PASSIFLORA (m/yLEA)	(2/2)
				MIRO (UFT)	(1/1)
				ASPLENIUM FL. (FR)	(4/4)
				PHYMATOSORUS (nFR)	(3/3)
				ANARTHROPTERIS (FR)	(1/1)
				MOSS/LIVERWORT	(1/1)
				(capsules)	(1/1)
FBU = Flower bud	RFT = Ripe fruit			INVERTEBRATES:	
FLW = Flower	SEE = Seed			– Scale insect	(2/2)
FR = Frond	UFT = Unripe fruit			– Caterpillar	(1/1)
FRT = Fruit				– Unidentified	(2/2)
LEA = Leaf (n = new, m = mature, y = yellow)				– Bagmoth	(1/1)

(x/y) : x = Total number of observations of kokako taking this food. y = Number of independent (different bird and/or date) observations.

4. DISCUSSION

4.1 Banding and Measurements

No problems associated with banding or the use of transmitters have been identified. Their use continues to provide useful information on the movements and general ecology of the species which will be crucial to the future management of the species. With the banding of nestlings this year we stand to gain useful information on juvenile survival and recruitment to the breeding population; information which will help us to predict the long term viability of the population.

Both tarsometatarsus and weight provide an indication of the sex of birds handled. When used together we can predict the sex of a bird with an expectation of over 80% reliability. To date this is based on a small sample size as ultimate sexing of kokako has relied upon the observation of respective nesting roles. We hope next year to more fully assess the usefulness of these measures.

4.2 Population trends

A small increase in the number of territorial adults and a doubling of the total chick output this year give us cause for cautious optimism about the future of this population under the current management regime. Of pairs which attempted to breed, 80% raised young; only 58% of pairs, however, made the attempt. The reason for this lack of attempts remains unanswered, but may involve food availability, habitat quality, sex, age and/or fitness of birds. It is hoped that long term monitoring of the population, as new individuals are recruited, and their major food plants will shed light on this issue.

Kokako generally form stable pairs which remain together throughout successive years. Individual banding of the population is revealing movements and turnover in some pairings which would not otherwise have been detected. Both sexes of kokako have been known to leave a previous pair territory 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 population.

At present kokako utilise an estimated 15% of Mapara forest area. Without knowledge of the criteria by which territories are selected we cannot guess at the likely carrying capacity, nevertheless it is likely to be considerably above the current density of 0.04 kokako per hectare.

At least 34% of the population remains unpaired. So far all long term single birds which have subsequently found mates have proved to be males. This lends weight to the suggestion that females are under represented in the population, because of a hypothesised greater vulnerability to predation. As banded juveniles are recruited into the population and replace aging birds we would expect to see a greater proportion of paired kokako in future years if this suggestion is correct.

4.3 Predation

Even at comparatively low densities, mammalian predators were considered to be the cause of at least three kokako nest predations. The recognition of the possum (*Trichosurus vulpecula*) as an important predator of nestling birds is of considerable importance to avian conservation in New Zealand. Under the current management regime, however, it appears that lack of breeding attempts has a far greater influence on the rate of population recovery than does predation. Only two pairs which lost nests to predation did not re-nest successfully.

It is not known to what extent trapping and poisoning of potential predators near nests contributed, over and above the effect of the poison operation, to the low rate of predation. Trapping results (Bradfield 1993) indicate that even at current low mammal levels every nest area was still visited by several predatory mammals.

4.4 Breeding

The onset of nesting was fairly synchronous with five attempts all beginning within a week. Timing of the first nesting (in late November) was very similar to last year, though in general most nesting was later last year. The timing this year coincides with the availability of ripe pigeonwood fruit which forms a major item of diet throughout the nesting period (18% of all feeding observations during November to March). Insects also provide a major food source during this period with 17% of all observations during this period.

Kokako lay between one and three eggs. In only one nest was an infertile egg located at the time of chick banding, though in some nests it was impossible to thoroughly search the bowl. Infertile eggs may sometimes be dumped by the parents. The average size of 11 successful broods in the past two years has been two chicks, including two broods of three. Following the loss of a nest four pairs re-nested; three were incubating new nests within ten days of nest loss whilst the other re-nested after three weeks. Kokako thus have a moderate reproductive potential and should thus be capable of a rapid population recovery if nest predation is minimised.

4.5 Nests

Several features of kokako nesting behaviour perhaps 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 below. This may leave scent trails for mammalian predator with a generally strong sense of smell. The strong smell of the bird, and only minimal efforts at removing chick faeces was often detectable by us and could undoubtedly be detected by predators which hunt by scent. Incubation of about 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 continue in its present form for one or two further seasons. This will allow the collection of data on the fate of nesting attempts for the full five year period over which the study was anticipated to run. During the first two seasons only chick production was recorded as our techniques of locating nests were as yet undeveloped. The banding should be continued, in particular emphasising the banding and subsequent monitoring of nestlings to assess rate of recruitment to the breeding population. Continuing the population study throughout a full five year period of mammal reduction will lessen the likelihood of false conclusions regarding the effectiveness of this control.

It is hoped that continuation of both feeding and phenological observations over a longer time frame may show up any linkage with kokako breeding effort. This aspect of the work will be fully written up at the completion of the five year period.

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

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