The Urban Release of Captive-Reared Kaka at Karori Wildlife Sanctuary

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Abstract

This study investigates the first reintroduction of captive-reared Kaka (*Nestor meridionalis*), an endangered parrot endemic to New Zealand, at Karori Wildlife Sanctuary, a predator free privately run sanctuary in the same vein as the Department of Conservation's mainland islands. Three Kaka from Auckland Zoo and three Kaka from Hamilton Zoo were released into Karori Sanctuary in August 2002 and followed until August 2003. The Kaka were fitted with radio transmitters, and coloured bands before release.

Before release, the consumption of supplementary foods was monitored and the Kaka were introduced to natural foods. The Kaka showed no significant temporal trends, and no correlation between the two groups. The Kaka showed marked preferences for some foods and very varied consumption of others. The Kaka instinctively foraged on natural foods that were provided. Provisioning of natural foods may have reduced neo-phobic responses and assisted successful transition to the wild.

Five of the six Kaka remained at the sanctuary 13 Months after release. The Hamilton Kaka tended to disperse further than the Auckland Kaka. All the Hamilton Kaka left the valley where as non of the Auckland birds did. RP-P left the valley and few to Island Bay eventually to return, RR-P went west to beyond Makara peak, and RW-P is the only Kaka to leave and not return. An un-banded wild male arrived at the sanctuary in January 2002 and has reminded since. RP-P and P-WY nested in December 2003 and 3 chicks fledged in March 2003, the pair nested again in 2004 along with RR-P and P-WB.

The largest part of the Kaka activity budget is foraging. Supplementary food is a large part of the Kaka diet and the more time a bird spent foraging on natural foods the less time they spent at the feeder. The Kaka at Karori developed a unique location call, and there was evidence of this being taught

to the Auckland Kaka by the Hamilton Kaka. Use of the feeder was taught to the wild Kaka that arrived and to the chicks.

These results suggest that captive-reared Kaka adapt well to release and supports Berry's (1998) findings. Captive-reared Kaka showed an ability to forage effectively on natural foods, had a high level of site fidelity, and formed stable population. Using captive-reared Kaka is an effective management tool, and the presence of an urban environment did not reduce the success of the release.

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CHAPTER 1:

General Introduction and Study Background

1.1 Introduction

1.1.1 The Kaka

The Kaka (*Nestor meridionalis*) is a forest-dwelling parrot species endemic to New Zealand. The North Island Kaka *Nestor meridionalis septentrionalis* is the subject of this study. The Kaka stands about 45 cm tall and weighs 425 to 575 grams. They live in the wild to about 14 years of age and can live up to 20 years in captivity (Heather and Robertson 1996). Males are about 5% larger than females in linear measurements of body size, and their upper mandibles are on average 12-14% longer, with a slightly larger radius of curvature (Bond et al. 1991). The bill dimorphism was not related to body size so Bond et al. suggested this was sexual dimorphism and may have been related to the utilisation of different niches by the sexes. Culmen length appears to be a useful means for distinguishing sexes in the field. The male Kaka has a culmen of 47 mm or more (juvenile male 44 mm or more) while the female is less than this (Moorhouse et al. 1999). Kaka are gregarious, social, friendly, intelligent, and very curious. They can be very conspicuous and make their whereabouts known to all, or they can be very cryptic as their feather colouring perfectly matches the colour of the foliage. They have yellow feathers around the eyes and a patch of white on the top of the head. Kaka also have a striking flash of red under the wings. The diet for Kaka consists of insects, sap, fruit, honeydew, shoots, seeds, wood pith and nectar (Beggs and Wilson 1987). They have strong sharp beaks that easily tear into bark to tap sap. Their rectangular tongues, tipped with 2mm long fimbriea and equipped with a spoon like depression, are well adapted to feeding on sap (Kirk et al. 1993). Kaka probably affect the function of New Zealand forest ecosystems by pollination of plants and the dispersal of their seeds.

1.1.2 Kaka taxonomy and evolution

Kaka and Kea (*Nestor notabilis*) are the two species of parrot in the genus Nestor. Kaka are usually divided into two subspecies: the North Island Kaka, *Nestor meridionalis septentrionalis,* and the South Island Kaka, *Nestor*

meridionalis meridionalis (Heather and Robertson 1996). The two species, Kaka and Kea, may have diverged in the last subduction event (maybe in the Pliocene 5 million ybp) that opened the Cook Strait The Otiran glaciation event 20,000 ybp lowered the sea level and may have allowed an overlap of the distribution of the two species. Sub-fossil remains of Kea have been found in the North Island in Otiran deposits (Holdaway et al. 1993) and Kaka still exist in the South Island, supporting this theory. The following interglacial period that started 10,000 ybp (McKinnon et al. 1997) raised the sea level again, separating the North and South Islands causing the stranding of the South Island Kaka and North Island Kea. The divergence of the North and South Island Kaka occurred after this event. The continuing warming of the climate to the present day may have resulted in the local extinction of the Kea in the North Island with Kea having evolved to live in cooler climates. By 14,000 years ago, the sub-alpine vegetation, an important part of the Kea's range had receded to mountainous regions reducing its range considerably (Holdaway et al. 1993).

1.1.3 Kaka populations and threats to the survival of the species

Kaka subfossils are frequent (Tennyson and Millener 1994), and it is known that they were once a common and widespread species until the early 1900s when humans arrived in New Zealand. The threat to populations of Kaka due to habitat degradation (for example from coupe-logging operations) is an ongoing present issue (Spurr et al. 1992). Once abundant, the Kaka has been in decline since the arrival of the Maori on the islands of New Zealand, 700-2000 years ago (Holdaway et al. 1993). Mammalian predators have seriously affected breeding in Duckpond Stream area South Island with only 4 successful breeding attempts in 11 years (Wilson et al. 1998). The loss of breeding females and nestlings from predation, combined with severe deforestation, and competition for food with introduces species (mammal, avian and arthropod) has resulted in Kaka now being restricted to predator-free offshore islands and a few large forest remnants (Figure 1.1) (Heather and Robertson 1996). The North Island Kaka now has retreated to localised flocks in large remnant forest tracts in the Coromandel, Wairarapa and the

central North Island ranges. Populations also exist on off shore islands including Hen and Chickens, Great Barrier, Little Barrier, Mayor and Kapiti Islands (Heather and Robertson 1996). The South Island Kaka are larger then their North Island counterparts and are not as common (Holdaway et al. 1993). The South Island Kaka resides in the forested parts of the South Island, Stewart Island and some smaller offshore islands.

The Kaka is now listed as endangered (IUCN 2003), and less than 10,000 birds remain (Heather and Robertson 1996). The perceived threats to Kaka are the degradation of habitat, competition for food from introduced mammals and insects, predation at nests by introduced mammals, and to a lesser extent shooting, hunting and poaching (Puller 1996). As hole nesting birds, Kaka females suffer greatly from predators, particularly Stoats (*Mustela erminea),* which hunt them while incubating (Wilson et al. 1998). This alters the sex ratio (Green and Fraser 1998) in favour of males and further exacerbates the threat to long-term survival. Interference to the pair bond from unattached males may cause the failure of that bond and therefore failure of the nesting attempt. The nestlings and newly fledged-chicks, which are unable to fly and spend the first few days on the ground, are also very vulnerable (Moorhouse et al. 2003).

Dilks et al. (2003) and Moorhouse et al. (2003) both found that uncontrolled stoat populations could reduce the breeding success rate of Kaka from 80% or more to 38% or less. Dilks et al. (2003) studied South Island Kaka in Eglinton Valley, Fiordland, and found that Kaka breeding was tied to Beech seed masting and that this brought the birds into direct competition with mice (*Mus musculus*) and rats (*Rattus* spp). However, breeding success could still be lifted to 80% or above if stoat traps were placed near nest sites. In a similar study, Wilson et al. (1996) found a 20% nesting success rate over 11 years in their study at Duckstream near the Nelson Lakes. Again most nesting attempts failed due to predation by stoats on nesting females, nestlings and new fledglings.

Kaka not only suffer direct predation as a threat, but also suffer displacement from their habitat by introduced competitors like the Brush-tailed possum (*Tricosurus vulpecula)* (Moorhouse 1997) and Wasps (*Vespula germanica* and *Vespula vulgaris*) (Beggs and Wilson 1991). Biggs and Wilson (1991) suggest that shortage of high-energy foods such as nectar and honeydew limit reproductive success. Possums and Wasps share a large dietary crossover with Kaka causing competition for food and placing extra pressure on Kaka. In the South Island Beech (*Nothofagus*) forests, Wasps compete with the Kaka for honeydew produced by the scale insect (*Ultracoelostoma assimile*). The honeydew is important for Kaka to meet their energy requirements. Food availability is often the limiting factor in Kaka breeding, even in mammal-free environments like Kapiti Island (Moorhouse 1997), so the impact of the extra pressure from competitors is significant. Kaka habitat is now restricted to small areas of forest remnants and offshore Islands with finite resources, so the importance of competition is greatly magnified. Spurr (1979) listed Kaka as a species that is unlikely to recover its numbers without management intervention. Spurr (1979) based this conclusion on a number of population dynamic and ecological criteria and emphasized the need to organise management under the umbrella of a single body, such as the Department of Conservation, to formulate a management strategy. The exact numbers of Kaka and their rate of decline are not known, and little is known about the health and sustainability of most populations. I found relatively little research has been done on wild Kaka. This lack of knowledge has left a gap in our understanding of Kaka ecology, and their management.

1.1.4 Management strategies

There is no formal document on wild Kaka management, and there is no recovery plan such as the Department of Conservation has for Kea (Puller 1996). What does exist are several conservation strategies proposed and implemented by researchers such as Ron Moorhouse and Terry Green. The Department of Conservation also has some general management policies including reforestation of suitable sites, the establishment of carefully managed Mainland Island reserves, and the control of introduced mammalian

predators (Stoats *Mustela erminea*) and competitors (Wasps *Vespula spp* and rodents).

Managing introduced predators and competitors helps mitigate the current population decline. However, reintroductions are necessary to restore Kaka to their former range and ensure the survival of the species. The benefit of reintroductions and translocations of endangered species are many-fold (Griffith et al. 1989). The population is distributed to more locations, lessening the danger of loss of the species by local disaster. The ecological processes of an area may be restored if the area was in the historical home range of the reintroduced animal. The effect of any animal, exotic or formerly native, on the ecology of an area must be identified and the impact understood before effective restoration is undertaken (Towns et al. 1997). The flow-on effects of an introduced species along and down the food web indirectly affects other species and alters the functioning of an ecological area, particularly if the introduced species has become a keystone species. Exotic animals may be performing an ecological function currently missing due to the local extinctions of native species and this must be considered. One other benefit of native species reintroductions is the ability to manage genetic distribution and diversity. Increasing the genetic diversity improves health of the population by ensuring the population has the genetic adaptability to any new disease that may arrive.

To date, most translocations in New Zealand have been to offshore Islands (Armstrong & McLean 1995). Historically the presence of uncontrolled mammalian predators and competitors has prevented reintroductions to the mainland. The main difficulty preventing the establishment of native animal populations on the main-land is the on-going control of mammalian pests and weed species (Logan 2001). New Zealand native species did not evolve in the presence of mammals, are not equipped to deal with mammal predation and competition, and never will be (Logan 2001). Therefore, the control of introduced animals will forever be a major management issue for New Zealand conservation. With the development of effective predator control measures, the Department of Conservation has been able to move on from

managing island refuges. The department has been able to create protected "Mainland Island Reserves" and has taken the next step toward returning our endangered avifauna to the mainland. The formation of private sanctuary like Karori, in the same vein as the department's mainland island reserves, and the integration of these sites into the conservation effort, is the evolution of this strategy.

Reintroductions have some management drawbacks (Griffith et al. 1989): they are expensive, success rates are varied, the population threshold for sustainability must be calculated and matched in the actual reintroduction, and the effect on the source population must be considered. If they are available, captive animal populations are a good source of animals to reintroduce as no threatened wild population is jeopardised. If the species in question breeds well in captivity, providing a ready supply of animals, and readily adapts to the wild on release, reintroduction may be a viable management strategy.

Kaka are easy to maintain and breed in captivity. Because of this, captive populations have become a valuable resource in the management strategy of the species. Raelene Berry (1998) did an important study of captive-reared and wild-caught Kaka released at Mount Bruce, providing an answer to whether captive-reared Kaka are adaptable to life in the wild. In 1996, four captive-reared Kaka and five wild-caught Kaka were released at Mount Bruce in the Tararua Ranges. The wild Kaka were held in the aviary for two weeks prior to release, so this was a soft release (Berry 1998). Berry (1998) found that four of the four captive-reared Kaka survived for at least six months after release and stayed in the vicinity of Mount Bruce. This suggested that captive-reared Kaka are capable of adapting to the wild and survival probability is high after release.

1.1.5 The Karori Wildlife Sanctuary

The Karori Wildlife Sanctuary is 2 km from the Wellington central business district (Figure 1.2), and consists of 252 ha of regenerating native forest. The

sanctuary is set up in the same vein as the Department of conservation's mainland islands, but with some important differences. Karori Wildlife Sanctuary is a privately operated sanctuary managed by The Karori Wildlife Sanctuary Trust. The long-term goal for the sanctuary is that it becomes fiscally self-supporting.

A predator-proof fence completely encloses the stream catchment valley that forms the sanctuary. The fence is a design and engineering triumph and was designed and developed in New Zealand, as there are no similar fences overseas to base designs on. The first step was to decide whether the valley would be a total exclusion fence for all mammals or not. The trust decided that nothing less than total exclusion would do in order to meet the vision for the valley. Extensive testing of fence designs was undertaken, and eventually Fletcher Construction built the fence along the ridgeline with a top hat design and mouse exclusion size mesh. Fletcher Construction won a construction award for the great difficulty that the steep and jagged ridgeline posed (I will testify to this, having had to swing from fence pole to pole on near vertical inclines on many occasions). The fence was designed to exclude Hedgehogs (*Erinaceus europaeus*), Rabbits, Mice, Rats (Ship Rats *Rattus rattus* and Norway Rats *R. norvegicus*), Stoats, Pigs (*Sus scrofa*), Goats (*Capra spp*), Dogs (*Canis familrus*) and Cats (*Felis catus*). Mice and one Rat (species unknown) have been the only mammals to reinvade the valley. The rats and mice are an ongoing control issue.

The valley flora is comprised of regenerating vegetation. From 1850 to 1960 the valley was used for farming. The western scarp was too steep to farm, so it was allowed to revert to forest earlier than the eastern scarp. That is were the best bush can be found now. To provide water for the developing city of Wellington, the Kaiwharawhara stream was dammed in 1871 (this is the stream that drains the valley catchment). This may have been the first dam constructed in New Zealand (Campbell-Hunt 2002). All stock were removed in 1906 to improve the quality of the water supply. The same year the second and larger dam was constructed to increase the capacity of the water supply for the ever expanding city.

Since 1869, the valley has also been mined. Because of the earthquake risk, the upper dam was decommissioned in 1991. The Wellington fault-line runs right up the middle of the valley and forms the streambed that dominates the geology of the valley. The lower dam was decommissioned in 1998 but has been retained as an emergency water supply. Pseudopanax spp, Coprosma spp, Rangiora (*Brachyglottis repanda*) and Kawakawa (*Macropiper excelsum*) now dominate the vegetation. On the eastern scarp, there are many Pine (*Pinus radiata*) trees (currently being harvested), Supplejack (*Ripogonum scandens*) abounds on the western scarp and occasionally there are stands of emergent Beech trees (*Nothofagus spp*) and Totara (*Podocarpus totara*).

The valley had been closed to the public for 120 years until James Lynch envisioned the concept of a Sanctuary in 1992. In 1996, the Trust was formed and the Wellington City Council gifted the valley to the trust after an extensive consultation process (Campbell-Hunt 2002). Financial support for the sanctuary is self-generated from visitor revenue and imaginative fund raising (e.g. selling the right to have your name on a fence post, seating or steps). The valley is now a major tourist attraction for the city, an important source of ecological study material for schools and universities, and an invaluable addition to conservation resources for the country.

1.2 Background to Kaka Release

Karori is now home to several of New Zealand's most endangered species including: North Island Robins (*Petroica australis*), Brown Teal (*Anas aucklandica*), Bellbird (*Anthornis melanura*), Tomtit (Petroica macrocephala), North Island Weka (*Gallirallus australis*), Little Spotted Kiwi (*Apteryx owenii*), and Saddleback *(Philesturnus carunculatus*). Raewyn Empson, the conservation manager at Karori, organised for the translocation and release of Kaka to the sanctuary, and In June 2002 six Kaka arrived - three from Auckland Zoo and three from Hamilton Zoo (Table 1.1). The Kaka were the chicks from the 2001-2002 breeding season, so were about a year old when

they arrived at the Karori Wildlife sanctuary. They still had the white ring around their eyes that remains until about 12 months of age (Moorhouse et al. 1995). The birds were released into the valley in August 2002.

There was no resident population of Kaka at Karori, and no wild-caught Kaka would be released with the captive-reared Kaka as at Mount Bruce. This meant that the Kaka at Karori would have no wild Kaka from which to learn survival. This was an important difference from the Mount Bruce release. The success of the release at Karori would not only support Berry's (1998) study, but would show whether captive-reared Kaka can be successfully released in a location with no other Kaka present. If the release at Karori proved successful, it would broaden the scope of releases in the future because more potential release sites could be considered.

This release and the release of other endangered species at the sanctuary are stepping-stones toward the vision for the sanctuary. The release of the Kaka into the valley heralded the return to the Wellington region of a bird that had been absent for over 50 years. It is the culmination of the two management tools, captive rearing and mainland island reserves, into one stratagem. This is therefore an important release in more ways than one. The success of the release will help determine the value of releasing captive-reared birds into an urban environment. The successful release of the Kaka will also add to the financial and ecological worth of the sanctuary enterprise.

This study involved following individual birds closely nearly daily for over 12 months. Never before have endangered birds that are such good travellers (capable of flying kilometres in a single day) been released free into a city environment. The proximity to the city brought into focus the question of site fidelity of the Kaka. The dangers faced by a wandering Kaka in the city are considerable and would be costly to the sanctuary. Monitoring the dispersal therefore became an important aspect of this study. Following the individual birds closely over the course of the study provided the unique opportunity to gather data on their foraging patterns over the period of the study.

Information was gathered on the use of supplementary and natural foods over the course of a year.

The release at Karori will add to the research by Berry (1998) by adding the information of a second captive-reared Kaka release. Berry's (1998) study only had a sample size of nine, and this study will be only six individuals, so combining the findings will provide a larger information base to build on. This study will improve future management of released populations and the use of captive-reared birds as source population for future releases.

1.2.1 The birds

Table 1.1 The Identity, sex, name, transmitter frequency and release date for each bird released at Karori.

Auckland birds:

Leg Bands	Sex	Name	Transmitter frequency	Release Date
P-YY	Female	Marama	85	23/08/2002
P-WO	Female	Uenuku	95	23/08/2002
P-WB	Male	Toomairangi	83	06/09/2002

Hamilton Birds:

Leg Bands	Sex	Name	Transmitter frequency	Release Date
RR-P	Female	Eden	91	27/09/2002
RW-P	Female	Jo	93	27/09/2002
RP-P	Male	Auf Wiedersehen "Alf"	81	1st 23/08/2002 2nd 06/09/2002

1.2.2 Research objectives

The main aims of this study is to determine the suitability of captive-reared Kaka for release into a relatively small, protected sanctuary; to monitor the behaviour, foraging patterns, and reproduction over a 12-month period; and increase the knowledge of Kaka translocations. The objectives of this study are:

1. To determine the survival rates of captive-reared Kaka released at Karori Wildlife Sanctuary, thus determining the effect of the release on the individual birds and determining the safety of such a release. By monitoring and following the individual Kaka over a 12-month period, this study will add to the knowledge of the long-term outcome of a release of captive-reared Kaka. The information gained from this study, and the data gained from Berry's (1998) study at Mount Bruce, can be used to determine if captive-reared Kaka can be successfully released into the wild. The use of captive-reared Kaka as a founder population in future releases can be determined. The management of Kaka populations both captive and wild now and in the future may be improved and modified by understanding the factors and processes involved in releases of captive-reared Kaka.

2. To monitor the dispersal of the released Kaka to determine if the Kaka will stay in the valley after release and where in the valley they will range. If the Kaka did not stay in the sanctuary, then the benefit to the sanctuary would be lost. Kaka lost from Karori sanctuary would be costly. There would be considerable financial cost to the sanctuary and the Kaka's zoo of origin. There would also be a high cost to Kaka conservation. Each of the Kaka in captivity are important as part of the Kaka captive breeding programme, and each individual is important for the survival of the species. Karori is in a unique position, being located close to a major metropolitan area. Because of this and the strong flight capabilities of the Kaka, site fidelity and dispersal are key issues. If the Kaka disperse out of the valley into the city, they expose themselves to dangers not present in a forest environment. Keeping the Kaka in the sanctuary will keep them safe, facilitate monitoring and financially benefit the sanctuary as the sanctuary can use the Kaka as an attraction. The value of using supplementary feeding as a method of gaining site fidelity can be assessed, and any other factors improving or affecting

site fidelity can also be determined. The management of future captive-reared Kaka releases can be improved to ensure success.

3. The movements of each Kaka monitored over the year will add to the knowledge of Kaka habitat selection and activity patterns. Where the Kaka disperse may show habitat preferences. The change in habitat preference over time could uncover factors important to Kaka ecology, such as their use of a given habitat and important socialisation behaviours. This may show important issues in regard to Kaka management. The choice of future release sites may be influenced by what dispersal patterns the Kaka show in particular release sites. This will improve release site choice, increase success of any future releases, benefit Kaka management, and give a better understanding of Kaka ecology. A better understanding of Kaka management and ecology will improve species survival chances.

4. During this study, information will be collected on the plant species the Kaka foraged for, and the food type collected from each species, e.g. sap, fruit, nectar or invertebrates. This may show responses to the change in food available over time. I hope to see whether supplementary feed intake was influenced by availability of natural foods or vice versa over the study period. The type of vegetation in the sanctuary is regenerating forest. The use of the vegetation available and the dispersal of the Kaka will indicate the suitability of such vegetation to support and sustain a population of Kaka. The important food species used by the Kaka and the type of food that was important during different times of the year can be determined. The carrying capacity may be shown if the Kaka disperse out of the valley to find food. Knowledge of this is vital for management of both captive and wild populations. This type of information will aid the decision-making processes around restoration of current protected areas, the location of release sites and the selection of protected areas in the future.

5. I was lucky enough to have a pair breed during my study. This was unexpected and so I was able to add a fifth objective, to monitor the growth, development, fledging and dispersal of four Kaka chicks. This included the nesting behaviour of the parents and the provisioning of chicks in the nest after fledging and into independence. This data will provide Information on how and with what parent birds provision their young, and how this affects chick development. This will aid future management of nesting birds in the wild. In this case, information will be

gained on how captive-reared parent birds adapt to nesting in the wild, and the success of such a nesting attempt. The success of a translocation to the wild depends on the Kaka reproducing and forming a sustainable population. The successful breeding of these captive-reared Kaka is the ultimate test of the success of the release, and for any future release of captive reared Kaka. This study represents the first time captive-reared Kaka have been observed breeding in the wild, so it provides important information on future management of nesting of captive-reared Kaka.

Chapter 2 covers the pre release use of supplementary food, the use of natural foods provided to the birds while in the aviary, and their behaviour up to and including the release. Chapter 3 discusses the release and investigates the post-release movements of the Kaka. Chapter 4 covers behavioural aspects and activities of the Kaka, and their foraging patterns on supplementary and natural foods over the 12-month post-release period. Chapter 5 covers the nesting period, the development of the chicks both pre and post fledging, and the behaviour of parent birds.

Figure 1.1: Bird Map

Presence/absence of each bird species was mapped in 10,000 × 10,000 yard grid squares. (AVHRR) satellite image collected and processed by Manaaki Whenua - Landcare Research NZ Ltd. http://www.rem.sfu.ca/gis/Projects/Eh/Nzbirds/

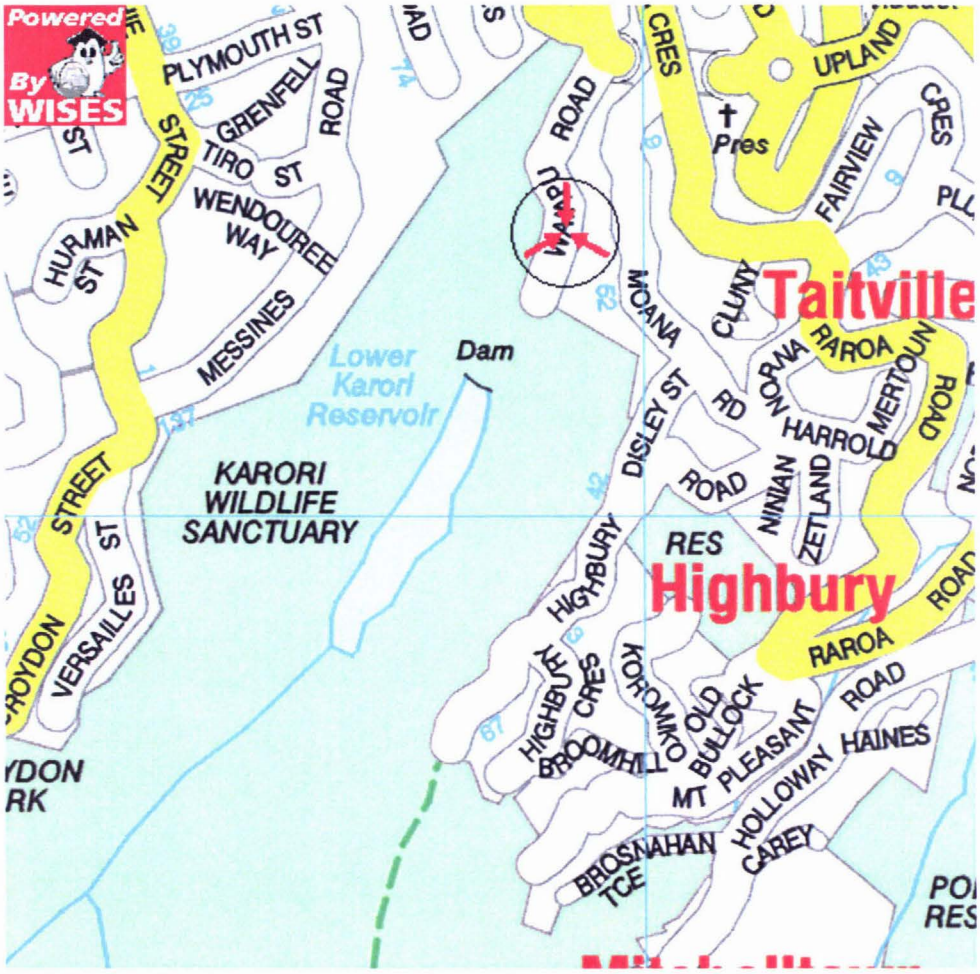


Figure 1.2: Street Map of Wellington City showing Karori Wildlife Sanctuary.
Source: http://www.wises.co.nz/

CHAPTER 2:

Pre-release Feeding and Behaviour

2.1 Introduction

Kaka dietary habits are not widely reported. Observations of how and what the Kaka chose to eat while in captivity will broaden knowledge of feeding patterns, and how Kaka use the food provided. This will benefit captive Kaka in the future and aid in the formulation of post-release feeding programmes. The way in which Kaka use the food will show what the most nutritionally important food groups are. Kaka may use more sugar water than other food types for example. This would show the relative importance of sugars for energy. This can then be extrapolated to the use of nectar and sap in the wild, and can show how much of this is required. We may then gage what natural resources are needed to support Kaka in the wild, so that in the future, ecological restoration plans can be geared to meet these needs. This will ultimately lead to improved restoration programmes, with better functioning trophic systems. A better understanding of the ecosystem will improve management. This will in turn lead to greater success rates for translocations, for not only Kaka, but other species as well.

Parrots are naturally omnivorous (Renton 2001), so the diet of the Kaka in captivity had to reflect the variety of foods they take in the wild. In the wild, Kaka take insects, pollen, and seeds for protein and fats. Nectar and tree sap are taken for sugars and energy. Plant shoots and fruit provide vitamins and minerals. Moorhouse (1997) studied the foraging patterns of Kaka on Kapiti. He found the diet of the Kaka varied to match the particular needs of the Kaka over time. Wild Kaka provided with supplementary food decreased their consumption of supplementary food when Beech seed became abundant. Kaka also switch from honeydew in summer to sap foraging in winter, when honeydew was not available (Beggs and Wilson 1991). Temporal shift in diet may also occur in captive birds as they may vary their diet in response to ambient air temperature or illness.

There is an underlying hypothesis that reintroductions of captive-reared animals have lower success rates than wild-caught animals (Bright and Morris

1994), and lack of experience may be the reason for this. To facilitate post-release foraging, the Kaka had natural foods introduced while still in the aviary. They were introduced to natural foods such as insects, branches, foliage, wild fruits and flowers. Fa and Cavalheiro (1998) found that wild Lucia parrots (*Amazona versicolo*) ate less, but ate a greater variety of foods than captive-born ones. If captive-reared Kaka do not utilize the variety of food available, they may become reliant on the supplementary feeding and not integrate successfully into the wild.

The way the Kaka use the natural foods while in the aviary may show potential post-release problems. It may become evident that the Kaka are neo-phobic while still in the aviary and avoid natural foods. This may indicate that they will not forage well on natural foods once released. Because of this, ongoing supplementary feeding of the Kaka was necessary. Supplementary feeding post-release may also be used to instil site fidelity. The supplementary diet post-release would be based on supplementary food consumption observed in the aviary. The monitoring of the Kaka food consumption was therefore necessary to determine the most important food items. Supplementary feeding would consist of a basic diet only, to minimize costs and time.

Understanding the needs of a species enables management to be geared towards providing that species with what it requires to be self-sustaining, and this is the goal of most translocations (Griffith et al. 1989; Armstrong and McLean 1995). A self-sustaining population is one that needs no support from humans, and is enduring. A translocation is successful if the population persists to the point were reproduction and individual replacement occurs. This means that the animals need to be able to meet all their nutritional needs through natural foraging. This is the ideal situation, but is not always achievable. In New Zealand, the constant pressure of mammalian predators and competitors means that independence from human intervention is generally not possible. Protected areas and reserves must be continually managed. This is the case with Karori Wildlife sanctuary.

This chapter investigates the consumption of the food provided in the aviary, both supplementary and natural, determining consumption patterns of the food groups offered, and any changes over time. Weighing the Kaka will determine if the nutritional content is being met, and indicate health. Changes in food consumption over time are recorded, and these are used to assess the extent to which food consumption might change with time, experience, and in response to changes in ambient conditions such as weather.

There were two groups of Kaka that came from different locations, and were held separately. This provided an opportunity to assess whether patterns of food consumption were similar for the two groups, or whether consumption might be affected by rearing history or social conditions. This will help provide information on the amount and composition of diet for captive Kaka in the future. In this way feeding regimes can be optimised to minimise cost, labour requirements, and complexity for the feeders, whilst maximising the nutritional benefits and variety for the Kaka. The use of natural foods provided while in the aviary will show preferences the Kaka exhibit for natural foods, and familiarise them with a range of vegetation and natural foods available in the sanctuary. I hope to be able to assess the ability of the Kaka to use natural vegetation before release, and determine if this is important for post-release survival.

2.2 Methods

2.2.1 Translocation to Karori

On 19/06/2002, the Kaka arrived at Wellington Airport. The Auckland and Hamilton Kaka were held at the Auckland Zoo in quarantine prior to departure from Auckland. The Hamilton birds arrived at Auckland Zoo on 08/06/2002. The Kaka were flown from Auckland to Wellington airports in several large wooden boxes with perches inside. The holding period for them at Karori was to be approximately three months, and the release was to be sometime in August. The aviary measured 6m x 3m x 3m, so allowed the Kaka small flights. Each of two groups was placed in aviaries at each end of the

structure, separated by a smaller aviary that held smaller birds from time to time. The Kaka were held on location to acclimatise. Therefore this release was a soft release (Bright and Morris 1994). The aviary contained a feeder, the same as the ones erected in the valley, to allow for familiarisation. The aviary also contained two nesting boxes, again the same as the ones intended for the valley. The aviaries had a solid roof over half of the structure to provide shelter. Many logs furnished the aviary, along with branches for perches and entertainment (ripping bark), and planted trees for shelter.

On arrival, each bird was banded with one pink metal band and two coloured bands. The large pink band was placed on the left leg of the Auckland Kaka and the right leg of the Hamilton Kaka. The coloured bands identified individuals (Table 1.1). The Kaka were weighed and the linear measurements taken including: culmen length and width, tarsus length, and wing and tail length (Appendix 1). The sex of each Kaka was determined by tarsus and culmen length (Moorhouse 1999). We had one male and two females in each group. The birds' weights were monitored to detect any major weight loss, which could be a symptom of illness or stress.

Transmitters from Sirtrack New Zealand Limited were attached to the Kaka on 22/07/2003. They were attached using a cord harness, with a weak link above the breast. The transmitters had a pulse rate of 20/60 (20 normal 60 in mortality) beats per min and a mortality sensor activating after seven hours of no movement. The transmitters were set on a 12-hour cycle, switching on at 08.00 NZST. The harnesses were checked for obvious misalignment by sight at feeding times, and more closely on capture at time of release. Several of the birds had to have harnesses refitted as the harnesses had caused rubbing under the wings, or had moved and were not sitting correctly on the bird.

2.2.2 Supplementary Feeding

As parrots, Kaka are opportunistic feeders (Moorhouse 1997). They need a wide a variety of foods to provide their energy and protein needs. It is therefore important that the diet of the captive birds meets these nutritional

requirements. The Kaka at Karori were fed a variety of natural foods to ensure nutritional content was covered, while providing variety for interest. The nutritional recommendations for Kea are similar to those of Kaka and are listed by Pullar (1996) as including: sunflower seeds, peanuts or walnuts in limited amounts, oats or other sprouted seeds, cheese (no more than 25g per bird per day), fresh green fruit and vegetables (washed thoroughly to remove spray residue). This is what the diet provided at the sanctuary consisted of, and will be referred to as supplementary food. Raewyn Empson, conservation manager at the Karori Wildlife sanctuary, designed the diet (Table 2.1). The diet was designed to give a varied diet including the foods listed above, and to incorporate a large component of what the birds had been eating at their zoo of origin.

2.2.3 The Feeders

The feeders were constructed at the sanctuary and were the same design as the ones in the aviary. The design was a wooden rectangle (with no centre, the wood formed a ring), and a stainless steel roasting tray that was fitted into the rectangle and could be removed for cleaning. A second larger rectangle formed a perch around the roasting dish. The feeders were constructed of untreated pine to avoid ingestion of toxic chemicals if the wood was chewed. The food was provided in metal dog bowls, placed on the roasting dish. Upright supports held up a wood semi-circular roof and the liquid food holder, which was made from plastic tubing.

A flap with a lever was later placed over the end of the plastic tubing to stop other birds from stealing the liquid food after release. The metal roasting trays were later replaced with Windsong feeders that only the Kaka weight could trip, again to stop theft (Plate 2.1). Windsong is the brand name for a commercially available feeder with a removable feed tray. A lid that is connected to a perch covers the tray. The weight of an animal on the perch in front of the food opens the lid. This was not entirely successful at stopping theft. I noticed a Saddleback (*Philesturnus carunculatus*) alight on the Windsong perch, but was initially unable to open it. It called and a second

bird alighted on the perch beside the first. The combined weight opened the lid of the feeder. It appeared to me that their behaviour was deliberate.

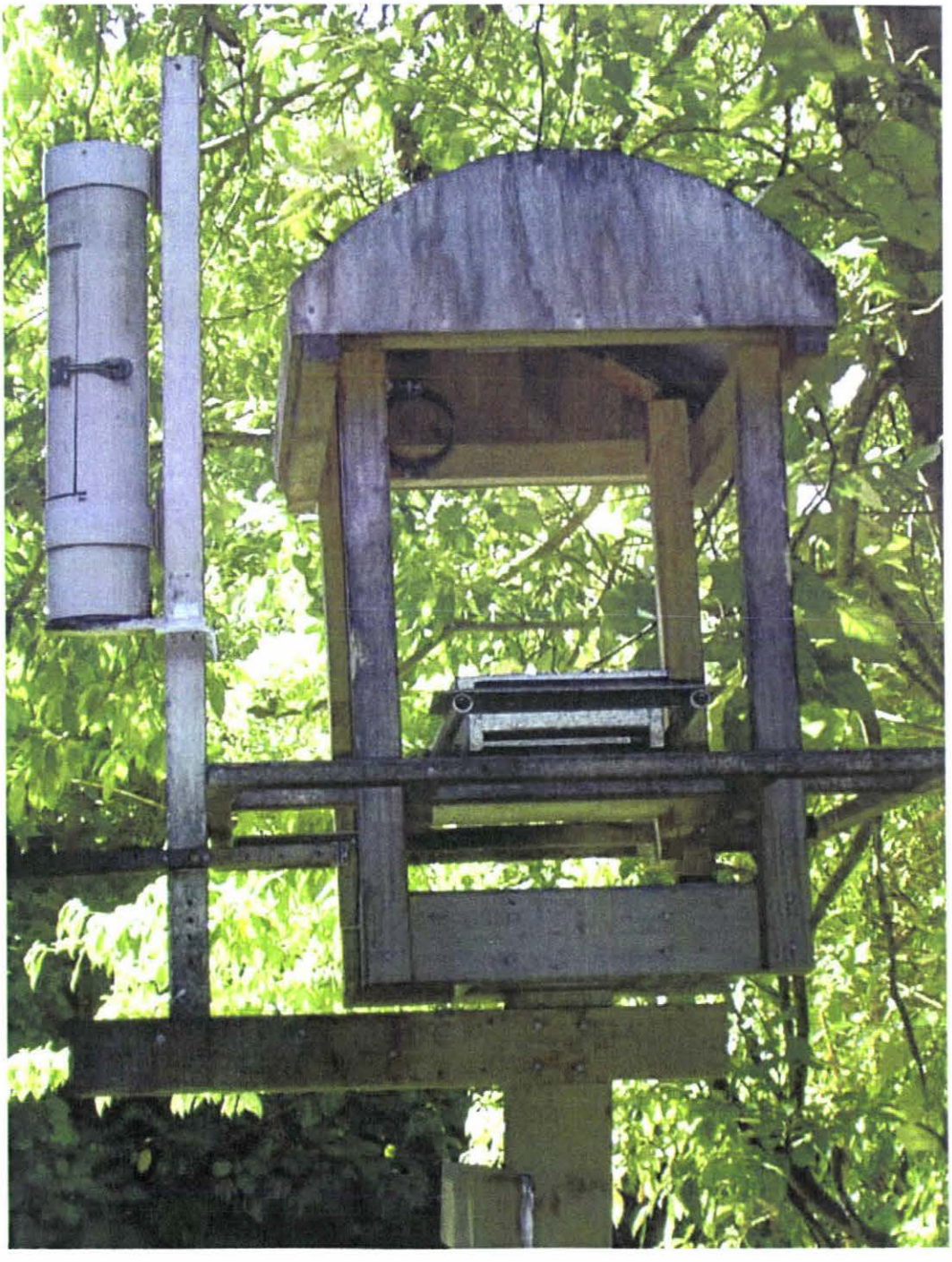


Plate 2.1: The dam feeder.

2.2.4 Supplementary Feeding

Volunteers fed the Kaka on a daily basis. By necessity, the method had to be cost effective, simple, quick and easy to prepare. Two people were rostered on for two consecutive days, but out of sync so that one partner's day one was the other partner's day two. A new partner was gained on the day two, ensuring some continuity. Inexperienced people always had someone with them who had done feeding before. This allowed sanctuary safety protocol to be upheld.

Making the jam water turned out to be one of the most time consuming tasks. The jam had to be "melted" in hot water, the mixture strained to remove the seeds, and bottled. Sugar is cheaper and easier to mix up than the jam water, so Raewyn Empson decided to replace the Jam water with sugar water after release on 27/09/2002. The sugar water was fed alongside the jam water from 31/08/2002 until the release, to see if the Kaka would take the sugar water as well as they had taken the jam water. This resulted in changing to sugar water after release. The jam and sugar water mixes were fed in 600 ml Coke bottles with a metal ball drip feeder designed for Rabbits. The Kaka were fed sunflower seeds and wheat mixture daily. Before being fed, half a cup of this mixture was soaked for three days in water allowing the grains to sprout. The mixture was washed and strained daily, and left to soak in fresh water. The seed mixture expanded to about double its size, and on day three, half the mix was given to each group.

Table 2.1: Average daily amounts of supplementary food provided to the Kaka.

Food	Amount
Jam Water	500 ml each aviary
Dates	¼ cup each aviary
Walnuts	½ cup each aviary
Corn	½ a frozen cob
Seeds (Mix of sunflower seeds and wheat)	½ cup daily
Fruit (seasonally available)	¼ cup daily
Carrots	¼ each aviary
Green Vegetables (seasonally available)	½ a cup each aviary
Cheese	1*1 cm^3 piece per bird
Sugar Water (Post 31/08/2002)	300ml each aviary

2.2.5 Provisioning with natural foods

The volunteers and the sanctuary staff assisted me in providing the Kaka with natural foods. As often as possible, I picked native foliage to give to the Kaka. We fed them mainly Coprosma (*Coprosma spp*) that were fruiting at the time. They were also given Five Finger (*Pseudopanax arboreus*), Rangiora *Brachyglottis repanda*), Kawakawa (*Macropiper excelsum*) and Hangehange (*Geniostoma rupestre*). On the odd occasion they were given broom flowers (*Carmichaelia spp*), Karo fruit (*Pittosporum crassifolium*), and Kowhai flowers (*Sophora spp*). Another treat was to place live Mealworms into holes in old

logs for the birds to search out. Observations of their preferences, and rate of consumption after feeding natural food were used to determine any consumption patterns and foraging behaviour.

2.2.6 Data collection

The Kaka consumption of the supplementary diet was monitored for the entire stay in the aviary, from 19/06/2002 to the final release on 27/09/2002. I helped construct a spreadsheet that would be used in the collection of data on the supplementary feeding in the aviary. The table had to be simple as volunteers had to use it in the field, but it also had to be flexible as the fruit and vegetables given varied according to what was available at the time. Foods that were fed consistently throughout were listed individually on the record sheet. The sheet design evolved as experience dictated, and ended up with one column for fruit and one for vegetables. However, because of this, the data for fruit and vegetables are crude. As the fruit and vegetables fed were lumped together, it is impossible to determine if any one particular type of fruit or vegetable was favoured over the others.

Other difficulties around the collection of the data on fruit and vegetables arose because the volunteers were supposed to remember what was fed the day before, but this did not always happen. In many instances the person taking the notes was not the person that fed the day before, or could not remember amounts of what was fed the day before. Food that was totally consumed may not have been recognised as having been present, and therefore not recorded. The amount of a food taken was not always noted and often only its presence recorded. In addition, intrinsic consistency problems arise whenever many people record data such as this. The nature of this data was also prone to objectivity problems and guesswork. The amount of food consumed is hard to accurately assess without weighing it before and after feeding.

A simple scale of 1, 2 or 3 was used to simplifying recording. This had the effect of standardising the data, but also took a lot of the definition out of the data. As this change happened halfway through the course of the aviary work

(18/08/2002 onwards), I effectively had two different data sets, and had to standardise the two. Reducing all the data to the percentage taken achieved this. For the data that was recorded on the 1, 2 or 3 scale, I replaced 1 with 100%, 2 with 50% and 3 with 0. This was not entirely accurate, but was all that could be done with the resolution of the data given. For the data that was recorded objectively, I had to standardise observations such as "a little", " a bit left" and "some" into percentages, "a little" became 10% and "some" became 20% and so on.

2.3 Results

2.3.1 Supplementary feeding in the aviary

Jam Water:

There was no distinct pattern to the jam water consumption (Table 2.2, Figure 2.1). The two groups of birds tended to eat half of the jam water on average. From time to time, the two groups of birds matched each other and consumed the same amount, but at other times the two groups varied considerably. There was one notable divergence between the Auckland and Hamilton Kaka, occurring about 16/08/2002. For several days the Hamilton birds did not take any jam water and the Auckland birds had a high consumption rate. The reason for the variation in consumption over time may have been a result of the weather, or what other food was provided that day. Alternatively, it may have been that the birds simply didn't like the mix of the jam water that day. The jam water was individually mixed and bottled and may have contained different mixes of jam and water, and this could have been the cause of the discrepancies noted.

Dates:

For the first three days after release, both groups of birds ate all of the dates (Table 2.2, Figure 2.1). After that, the consumption varied from 0 to 100%. Despite this, the consumption pattern for both groups seems to parallel each other. Consumption levels seemed to vary much more in July than during the other times of the year with no distinct pattern. In the last month in the aviary,

the consumption level went down dramatically. Only three times in August did the Hamilton birds consume over 50% of the dates, and only twice did the Auckland birds do the same. There were also many occasions when consumption was zero during this period. From 18/08/2002 until the first release, the consumption averaged 50% for both groups. The fact that consumption levels for both groups of birds remained similar may be due to the quality of the dates being the same for each group. However this was not the case for the jam water. The variation in consumption for dates may be revealing variation caused by the temperature altering metabolic rates.

Walnuts:

The walnuts proved to be the most popular food for both groups (Table 2.2, Figure 2.1). Usually the walnuts were taken first, and usually all was consumed. In June the rate dropped from 100% only twice. The drops coincided for each group on two consecutive days. For the entire aviary stay, the Hamilton birds had 11 occasions where they did not eat all the walnuts, but consumption dropped to 80% or less only nine times. The Auckland birds had eight instances of a consumption rate of 80% or less. The two groups dropped to 80% or less with an equal rate. On three occasions the Auckland birds did not eat any walnuts. The Hamilton birds always ate at least some walnuts and never had a zero rate of consumption. Overall, the walnuts were by far the most consistently consumed food, and remained top of the list for the entire duration. The consumption rate varied most in the final month, between the 8/08/2002 and 20/08/2002.

Corn:

For the first two days the birds were in the aviary, all the corn was eaten (Table 2.2, Figure 2.1). However, in the first month the consumption was relatively low and only reached 100% twice. Consumption varied considerably day to day, with no distinct pattern. The consumption pattern for the two groups of birds did not seem to correspond either. When one group had very high consumption, the other group often had very low consumption. There was a long period of low corn consumption in both groups lasting most of July, only going above 20% on two occasions for each group. Both groups

ate 80% on the same day (30/07/2002) and this was the only outlier for July. A similar jump was not noted in any other food group on that day. Consumption in August was a lot more varied than in July, and the overall consumption increased. In August, the consumption reached 50% or more only three times for the Hamilton birds. The Auckland birds were more varied than the Hamilton birds and exceeded 50% seven times, twice eating all the corn on two consecutive days (20/08/2002 and 21/08/2002).

Seeds:

On the first day in the aviary the Auckland birds ate all the seeds (Table 2.2, Figure 2.1). However the Hamilton birds did not eat any. For the next few days, neither group ate any seeds. On day four, consumption levelled out for both groups of birds, and although fluctuating, it remained around 50%. The two groups often had the same consumption level and varied on average only 35%. After about the second week in July the range in consumption varied more than previously. There seemed to be no pattern for peaks and troughs, and the two groups did not seem to consistently match each other. In August, the figures were matched for Auckland and Hamilton for 12 out of 23 days. There were several stretches when the consumption remained the same for several consecutive days. Both groups had the same end point of 45%. The figures showed that the seeds were a consistent and important part of the diet.

Fruit:

The Kaka were fed fresh fruit daily (Table 2.2, Figure 2.1). The fruit given varied depending on what was available at the time. Apples, oranges, pears, grapes, kiwi fruit, tamarillo, and banana were among the fruit given. During the first month in the aviary, the consumption was very similar for both groups, differing only three times. After this, consumption became more varied between the groups, but was also the same on many occasions. From about 09/08/2002 consumption between the two groups again matched becoming the same for the two groups on many occasions. Varied consumption may have been due to the Kaka favouring some fruit over others. Some of the fruit

was consumed entirely on one day, and often not touched the next. The reason for this is not known, but may have been due to the freshness of the fruit, and whether it had been sitting in the fridge or not. No clear favourite fruit emerged. Overall the consumption tended to trend upward peaking about the last week of July. An overall downward trend in consumption in August for both groups followed that peak. Consumption fluctuated wildly at the end of that month.

Carrots:

The carrots were not peeled, but were washed and topped (Table 2.2, Figure 2.1). The pattern of consumption for the birds varied considerably from day to day, but was nearly identical between the groups, differing only slightly on a couple of days. There were few occasions when consumption varied considerably between the two groups. The remainder of the time the two groups varied by only 10-20%. Although the two groups did not vary considerably, the variation between days was considerable. There seemed to be no pattern to the variation over time. However there was a period at the beginning of August when consumption was very low for about a week and a half. The Kaka may not have liked carrot from the fridge, or older carrots and this may explain the daily variation. This may also explain the consistency seen between the two groups. The noise of individual fruit preference that may be evident in the fruit data is not present in these data.

Green Vegetables:

The Kaka were fed whatever green vegetables were available at the time (Table 2.2, Figure 2.1). They were fed broccoli, celery, and cabbage, and also frozen Watties vegetables thawed over night, e.g. peas and beans. Cooked kumara and pumpkin were also given. Most of the green vegetable data are missing for the first month. During the second and third months, consumption tended to vary considerably over time between the two groups of birds. However, data were often missing from this food group making it very difficult to detect a pattern in consumption. Again it was noted that the birds

tended to like very fresh vegetables, and not ones that had been sitting in the fridge too long. They did eat peas, however, without regard to freshness. They ate the cooked pumpkin and kumara, but tended not to eat a lot of it and it was not a favourite. The peaks and troughs of the two groups did tend to follow each other, so this suggests that both groups ate and favoured the same vegetables.

Cheese:
Again the amount of missing date has hindered the observation of an accurate trend (Table 2.2, Figure 2.1). No data was collected on cheese consumption until the end of the second month, and even then the data was patchy. Cheese may not have been recorded as the assumption by the volunteers could have been that it had not been fed. In fact it may have all been eaten. I do not think this is the case however, as the missing data was too consistently missing. The recording started at about the time the recording sheet was modified and simplified, and I think this change had more to do with the increase in recording cheese consumption. From the data obtained no clear pattern emerged either over time or between the two groups.

2.3.2 Feeding post first release

After three of the birds were released on 23/08/2002, the remaining birds were housed in one aviary (Table 2.2, Figure 2.1). When RP-P was caught again (see chapter 3) on 25/08/2002, he was reintroduced in the same aviary as the other three birds. He and P-WB were released (second release) on 06/09/2002. The recordings of food consumption taken over this time therefore included an aviary of up to four birds and as few as two birds.

The amount of dates eaten gradually increased from 25/08/2002, reaching a maximum of 100% eaten on the 01/09/2002. It dropped off after the release of RP-P and P-WB on the 06/09/2003, and sat around 50% until just before the final release. The Kaka usually consumed all the walnuts. Usually half of the corn was consumed. However on days when it was less, none of the corn

was consumed at all. The Kaka usually ate 50% of the seed mix. However on four days none was taken, and on four days 70-80% was taken. Fruit was more variable but usually the level of consumption ranged between 0 and 50%, only going above this twice (on the 05/09/2002 and 12/09/2002). Carrot was either about 50% taken (the usual situation) or none taken. Only once was this not the case, on 26/09/2002 when all the carrot was taken. The consumption of greens was quite varied but usually less than 50%. It moved above this a little on occasion, but only went to 100% once on the 10/09/2002. The Kaka consumed more cheese as time went on.

Table 2.2: Table of percentage of food group consumed for each month. Consumption included for both Hamilton and Auckland aviary and the one remaining aviary left occupied after release of P-WY and P-WO on 23/08/2003. The food categories are: jam water, dates, walnuts, corn cobs, seed mix of wheat and sunflower seeds, fresh fruit (subject to availability), carrot, green vegetables (subject to availability), cheese and sugar water.

	Jam water	Dates	Walnuts	Corn	Seed	Fruit	Carrot	Greens	cheese	Sugar water
June Hamilton	9	13	28	2	13	12	14	7	2	0
June Auckland	12	14	26	2	13	14	11	5	2	0
July Hamilton	12	11	31	5	14	9	5	10	4	0
July Auckland	17	10	26	8	12	8	6	9	5	0
August Hamilton	14	15	25	12	8	11	12	3	0	0
August Auckland	12	13	26	14	2	9	11	3	0	0
August post-release	12	8	31	10	16	5	8	8	2	1
September	12	11	23	9	10	8	9	8	8	2
% of food group consumed while in the aviary	12	12	26	6	12	10	10	7	4	1

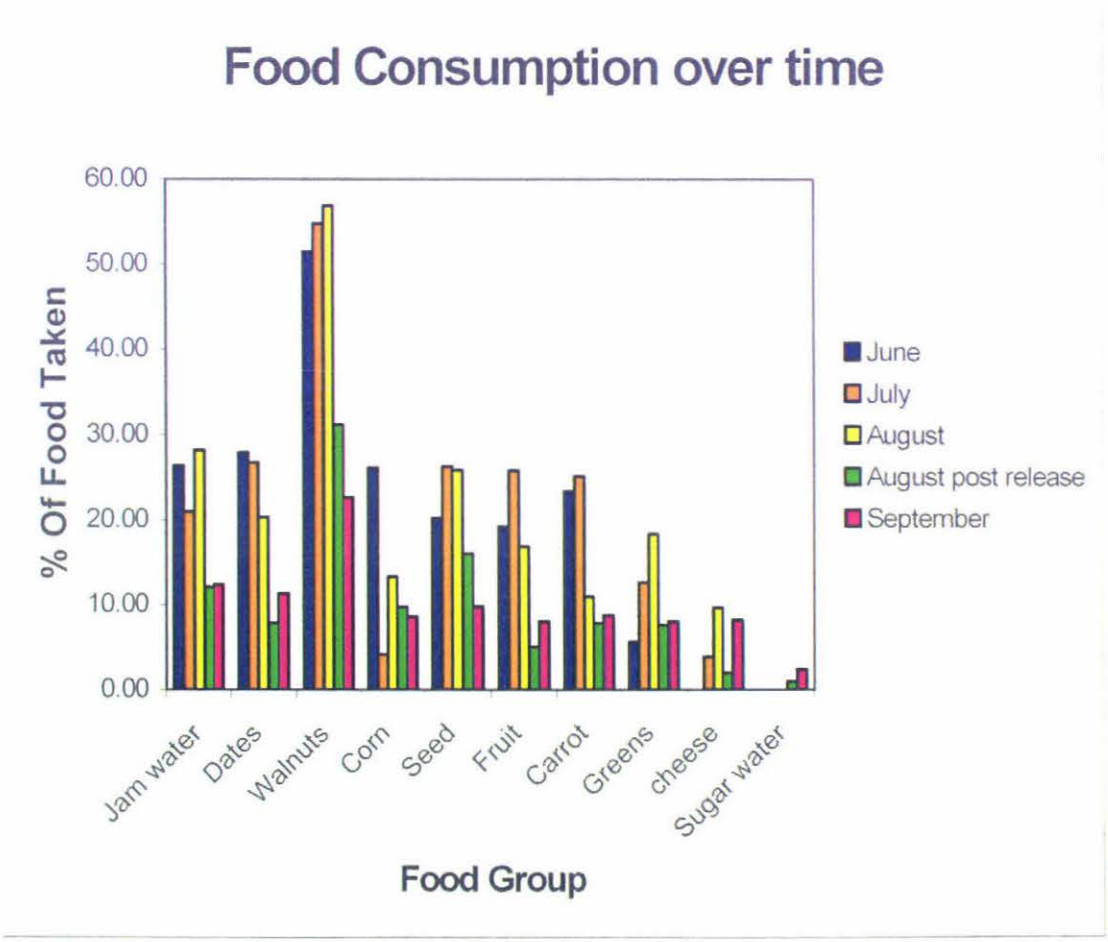


Figure 2.1: Percent supplementary feed taken for each in each month.
August has been divided into pre release of P-WY and P-WO on 23/08/2003 and post-release August data

2.3.3 Weight Gain

The Kaka were weighed when they were in hand for fitting of transmitters, banding, and for checking of harnesses holding on transmitters.

Table 2.3: Weights (g) of individual Kaka while in the aviary at Karori.
Decreases shown with asterisks.

	19.6.02	3.7.02	21.7.02	22.7.02
P-WY	350	355	354	361
P-WO	354	359	358	363
P-WB	426	376*	434	438
RR-P	372	389	395	386
RW-P	397	407	429	385*
RP-P	403	399*	428	419*

Five of the six birds gained weight gain over time (Table 2.3). Two birds initially lost weight. P-WB lost 50 g and RR-P lost 4 g in a little less than a month between 19/06/2002 and 03/07/2002. Both recovered their weight rapidly, with P-WB gaining 58 g in the subsequent 18 days. RW-P was the only bird to have a total weight loss despite an initial weight gain. RW-P lost 44 g in one day between 21/07/2002 and 22/07/2002. This was possibly related to an injury to her foot, but may have been an error in weighing. The next weighing was not done until her release on 06/09/2002, and her weight then was 425 g. She had started to recover her weight. RR-P was the most variable initially losing 4g then gaining 29 g and finally dropping again by 9 g.

2.3.4 The Statistics

Regression analysis was used to test for trends in consumption of each food group over time, and correlation analysis was used to test for correlations between the Hamilton and Auckland Kaka in temporal patterns of food consumption. These analyses were done using Minitab (Table 2.4).

Table 2.4: Regression analysis to assess whether there was a tendency for the consumption of each food to increase or decrease over time.
The dependent variable is the % of the food consumed in a day, and the independent variable is the number of days (*d*) after the birds were put the aviary (for the three Hamilton and three Auckland birds) or the number of days after 24/08/2002 (for the birds remaining after the first release).

	Group	Regression Equation	*F*	*P*
JAM WATER	Hamilton	$\% = 33.7 + 0.003d$	0.559	0.458
	Auckland	$\% = 54.3 - 0.001d$	0.059	0.808
	After 24/08/02	$\% = 62.6 - 0.005d$	0.82	0.372
DATES	Hamilton	$\% = 29.0 + 0.007d$	2.177	0.145
	Auckland	$\% = 49.5 - 0.002d$	0.149	0.701
	After 24/08/02	$\% = 46.7 - 0.001d$	0.01	0.922
WALNUTS	Hamilton	$\% = 96.2 - 0.003d$	0.656	0.421
	Auckland	$\% = 92.0 + 0.002d$	0.956	0.332
	After 24/08/02	$\% = 100 + 0.000d$	-	-
CORN	Hamilton	$\% = 11.6 + 0.003d$	0.645	0.425
	Auckland	$\% = 2.7 + 0.013d$	7.353	0.009
	After 24/08/02	$\% = 44.0 - 0.004d$	0.81	0.376
SEEDS	Hamilton	$\% = 43.3 - 0.001d$	0.083	0.774
	Auckland	$\% = 43.8 + 0.002d$	0.471	0.495
	After 24/08/02	$\% = 34.5 + 0.007d$	3.93	0.056
FRUIT	Hamilton	$\% = 31.5 + 0.004d$	0.909	0.344
	Auckland	$\% = 35.6 + 0.004d$	0.801	0.375
	After 24/08/02	$\% = 40.7 - 0.004d$	0.58	0.454
CARROT	Hamilton	$\% = 21.8 + 0.009d$	3.350	0.072
	Auckland	$\% = 30.6 + 0.004d$	0.781	0.381
	After 24/08/02	$\% = 41.9 - 0.002d$	0.24	0.631
GREENS	Hamilton	$\% = 40.5 - 0.000d$	0.001	0.970
	Auckland	$\% = 38.7 + 0.003d$	0.121	0.730
	After 24/08/02	$\% = 40.2 - 0.002d$	0.09	0.771
CHEESE	Hamilton	$\% = 25.6 + 0.004d$	0.132	0.722
	Auckland	$\% = 33.4 + 0.007d$	0.343	0.569
	After 24/08/02	$\% = 20.0 + 0.017d$	2.32	0.145
SUGAR WATER	After 24/08/02	$\% = 54.6 - 0.008d$	1.00	0.364

There was an overall increase in consumption of most of the food groups for both groups of birds over time (Table 2.5). However, the increases were generally not statistically significant. Decreases were recorded for the Hamilton Kaka in walnuts, seeds and vegetables, and for the Auckland Kaka in jam water and dates. However, none of these declines was statistically significant. The only significant statistic at the 0.05% significance level was the increase in consumption over time of corn by Auckland Kaka ($p = 0.009$).

Table 2.5. Correlation analysis to assess how closely temporal trends in food consumption matched for the Auckland birds and Hamilton birds.
r values show Pearson correlation coefficients.

Food	*r*	*P*
Jam Water	0.381	0.004
Dates	0.141	0.284
Walnuts	0.234	0.062
Corn	0.304	0.021
Seeds	0.184	0.155
Fruit	0.212	0.106
Carrot	0.722	0.000
Vegetables	0.573	0.001
Cheese	0.266	0.430

The patterns of consumption over time were positively correlated for the Hamilton and Auckland birds for all food types (Table 2.5). The Pearson correlation coefficient, *r*, ranged from 0.14 for dates, to 0.72 for carrot. There were significant correlations between the Hamilton and Auckland birds in consumption of jam water, carrot and vegetables.

2.3.5 Natural foods

The Kaka liked any fruiting and flowering plants given and chose these specimens first. They then moved on to stripping the bark off the branches, and ate the wood pith or licked the sap from under the bark, particular for Five finger. This activity often kept them busy for hours. They favoured Five finger and Coprosma branches best, particularly last years growth with a diameter of about 1 cm to 1.5 cm and with bark that was still soft. Anything larger than 2 cm had its bark stripped for bugs or grooves gouged out to tap sap. Anything less the 1 cm was discarded. They tended to stay away from the Kawakawa, but did eat it on occasion.

The Kaka seemed to instinctively know what to eat and how to eat it, and had preferences that they established quickly. In the end, I ended up being trained by them, spending a lot of time hunting down their favourites to keep them happy and amused. The Kaka always chose the natural food over the supplementary. The Kaka got stimulation from stripping the bark, and often sought out this stimulation by attacking the branches while still in my hand.

2.3.6 Behaviour

The birds of each group did not seem to show any dominance hierarchy. Each bird was just as likely to peck or chase any other off the food. The males did not seem more dominant than the females, being just as likely to be on the receiving end of abuse as to be giving it. The Hamilton birds did seem to be the more outgoing and adventurous. RP-P tried sitting on Denise's head once while still in the aviary and this was a sign of his strong personality. Female RW-P had a habit of walking along the top of the cage and then down the side. She then would move along the branches and up to the roof of the cage again. She would do this for hours. She lost a claw when it was torn out at the root. It was surmised that she caught it between section joints on the roof of the cage. She was the only one who did this at first, but after about three weeks the other two in the aviary with her (RP-P and RR-P) also showed this behaviour. They did not do it as consistently, or for as long as RW-P. The birds in the Auckland cage did not develop this behaviour.

2.4 Discussion

In this chapter, the use of supplementary and natural food groups was investigated. I found that favorites emerged among the different food groups, but there was no significant correlation between the two Kaka groups and no significant trends over time emerged.

2.4.1 Provisioning of supplementary food

Meeting nutritional and energy requirements is the most important consideration when formulating a diet for captive birds. While in captivity, the supplementary diet had to provide all of these needs, so ensuring all needs were met was a matter of survival. The supplementary diet had to provide components that a wild Kaka's natural diet would provide. In the wild, Kaka get protein from insect grubs, and this is an important part of their diet. They spend 35% of their time foraging for them (Beggs and Wilson 1987). While in the aviary, the percentage of the diet consisting of high protein foods (walnuts and cheese) was 30%. If proportion of consumption of protein in the aviary represents time spent foraging on protein in the wild, then we can estimate the importance of protein in the diet of captive Kaka as being similar to that of wild Kaka. A 593 g Kaka needs about 490 kj per day from sap, nectar insect fats or honeydew (Beggs and Wilson 1987), the choice of supplementary food taken tended to be those with a high-energy content like walnuts and jam water reflecting this. Beggs and Wilson (1987) found a similar tend with the captive Kaka in their study with the birds only taking Sunflower seeds, Corn and Apple. Pryor et al. (2001) suggested that in frugivorous birds such as parrots, protein might be a limiting factor. In Pesquet's Parrot (*Psittrichas fulgidus*), they found 3.2% dry mass of protein is required to prevent nitrogen loss.

Jam water and later sugar water were important to provide energy needs. Kaka and other New Zealand parrots have 32% higher basal rates than expected for body mass, 21% higher than for then that of tropical species. The basal temperatures were due to large flight muscles and lower ambient

temperatures (McNab 1995). It is clear that without correct nutrition, illness and disease can develop. Nutritional deficiencies can cause a number of illnesses in pet parrots feeding on supplementary food. Shoemaker et al. (1999) lists these illnesses, including: Hypovitaminosis A in the whole parrot family, hypocalcemia in the African Grey parrot (*Lophopsittacus bensoni*), and goitre in budgerigars (*Melopsittacus undulatus*). Obesity can lead to fatty liver disease and lipoma in Galah (*Cacatua roseicapilla*), Amazon parrots (*Amazona ochrocephala*), and Budgerigars. Meeting nutritional requirements is particularly important if captive breeding is intended (Berry 1998).

Pullar (1996) suggests that Kea will meet their own nutritional needs by eating what they need. Most birds will probably do this. Monitoring the Kaka dietary habits will determine if Kaka also do this. Consumption patterns that emerge can be used as a guide to determine the most nutritionally important foods. The list of foods fed can then be narrowed down for simplification of the diet, and at the same time the most important food groups and food groups with the highest consumption rates can be provided in a variety of forms, e.g. if nuts prove important different types of nuts can be provided. This will meet all the nutritional needs of the Kaka efficiently, while still providing maximum dietary variety. Fa and Cavalheiro (1998) conducted a study on supplementary food intake in St Lucia parrots (*Amazona versicolor*), to determine whether information on consumption patterns can be used to create optimal supplementary diets. They found that one could not generalise the diet for the whole species from measuring food consumption of individual birds. Individual preferences make quantification of intakes too varied for each bird. However, they point out the usefulness of using this information to formulate diets for captive birds.

The diet fed at Karori was designed in this way, with the foods used most forming the largest component of the diet. However, while in the aviary other factors had to be considered when formulating the diet. The Kaka needed to have all nutritional needs met by the supplementary food. Variety also had to be maintained for behavioural reasons, including environmental enrichment and broadening dietary experience. The supplementary diet fed at Karori was

designed to include food the Kaka had been exposed to at their zoo of origin. Doing this provided continuity of diet to prevent problems arising from foods the birds were not used to, and to ease the transition to the new environment.

The lack of changes in consumption patterns suggests that the environmental changes occurring at Karori were not sufficient to induce a change in consumption levels. I would have predicted that the consumption rate of the Kaka would have decreased over time as the ambient temperature got warmer, but this was not observed. The Kaka were only in the aviary for a little over two months, and changes in consumption due to ambient temperature may have been observed if the Kaka were kept in the aviary for an entire year. Food consumption between the two groups was not closely correlated either, and this suggests that individual Kaka may have different nutritional requirements and fulfill their needs in different ways. Temperature fluctuations were identical for all the birds and therefore energy requirements should be the same for all birds. Something other than temperature may have been driving food choice. Individual taste may play a large role in food choice for Kaka. Fa et al. (1998) found that individual Lucia parrots (*Amazona versicolor*) have significant different levels of individual consumption. This may also have been evident in this study. The amount of fruit eaten varied considerably day to day, and was not consistent between the two groups. The difference between the two groups suggests that food dislikes are different between the two groups and individual choice is evident.

Birds in captivity can develop a variety of nutritional deficiencies and commercially supplied diets are designed to provide nutritional needs and prevent these deficiencies (Schoemaker 1999). There is a commercial diet available for Kea in captivity (Pullar 1996), and this can probably be given to Kaka as well. However, a formulated commercial diet would not give the Kaka the variety that is needed to stimulate them. Mettke-Hofmann et al. (2002) discussed the presentation of novel items to parrots to reduce neophobia. This promoted exploration activity, and reduced fixation on one particular thing. If Kaka are successfully going to integrate into the wild environment, they will also need these skills.

2.4.2 Provisioning of natural foods

I found that the Kaka responded quickly and decisively to the natural foods provided. They instinctively knew what to eat and how to eat it. Berry (1998) found that the captive-reared Kaka, which used the supplementary feeder, did not have a different natural food diet than the wild-caught Kaka. This supported what my findings suggest. Kaka are able to find natural foods in the wild even after being raised on an "artificial" supplementary diet. This suggests that providing the Kaka with supplementary food after release is not essential for survival. It may be important in other ways however. Supplementary feeding may encourage site fidelity and provide a fixed point the Kaka can use to orient toward (Berry 1998). It may ease the transition to the wild by providing familiarity. It may also help to provide support for the Kaka during times that they cannot find enough natural foods on their own. The fact that they know what to eat, and how to find food instinctively, meant that they could become self-sufficient sooner.

3.4.3 Weight fluctuations as a sign of health.

The Kaka at Karori had weight gains of between 9-16g in a little over one month. Only one did not put on weight. This suggests they were in good health and thriving in their new habitat. The Kaka were about a year old when they arrived and may still have had some growing to do, explaining the increase in weight. There was some fluctuation and some birds experienced weight loss at some stage during confinement in the aviary. RW-P may have lost weight due to her foot injury or her neurotic personality tendency. The exact date of her injury was not recorded, but was around the time the weight loss began. The rest of the Kaka at Karori all put on weight. Although weight gain can cause health problems, in this case it provided the Kaka with fat reserves to assist survival once released. In the long-term Kaka could develop weight related health problems, but they were only temporally in captivity and their weight should normalize after release. Their weights did not exceed the upper limit of 550 g for Kaka weight noted in the literature (Heather and Robertson 1996).

The weight loss experienced by some of the Kaka after they arrived at the sanctuary may have been due to stress from the move. Armstrong and Perrott (2000) used weight loss in Hihi (*Notiomystics cincta*) as a sign of starvation. The weight loss of the Kaka could show similar starvation. The stress of the new environment, illness, or the change of diet could also cause the Kaka to lose weight. If this happened some form of intervention would be required to ensure the health of the Kaka. Weighing while in the aviary will effectively monitor for these conditions, and provide a baseline weight for future reference. The way other captive populations respond to supplementary food can be compared to the way the Kaka at Karori responded. The type of supplementary food given could cause different patterns of weight loss or gain. If this is the case, then this information can be used to improve supplementary feeding, and the needs of a specific population targeted.

2.4.4 Foraging Ecology

Mettke-Hofmann et al. (2002) studied neo-phobia to determine the differences in exploratory behaviour in different parrot species. They found that island-living birds have a lower level of neo-phobia, and are therefore pre-adapted to exploration and to new habitats. Meehan and Mench (2002) found that Orange-winged Amazon parrots (*Amazona amazonica*) showed less fear response. A repressed fear response can allow parrots to adapt more easily to a changing environment. The Kaka at Karori were provided stimulation with novel food items, and may have adapted better to release because of this. If this is the case, then management must be implemented around the ecology of island parrots as opposed to continental species.

The reduction in neo-phobia may also have benefited the Kakas' social development. If they are quick to interact with the environment, they may be quick to interact with each other. This will lead to the development of the complex social structure that is observed in Kaka. Kaka are flock birds and benefit from social interaction. Syndel (1994) found that a lack of socialisation

and foraging experience in captive-reared thick-billed Parrots (*Rhynchopsitta pachyrhyncha*) adversely affected survival rates on release. The number of individuals released directly influenced translocation success. Releasing more birds increased ability to forage effectively, as the collective experience was greater. P-WY revisited the aviary area after release, and interacted with the Kaka remaining in the aviary before their release, emphasising the importance of social interaction for Kaka. Pullar (1996) suggests that Kea should be kept in groups for this reason, and suggests that mal-adjustment can result from Kea remaining solo. As close relatives of the Kea, this may be the same for Kaka.

No dominance hierarchy developed among the Kaka at Karori. The Kaka at Karori were all siblings within their respective groups, so this may have been the reason that no dominance emerged. The lack of a distinct dominance hierarchy could also reflect the lack of need to compete for an abundant food supply. Both natural and supplementary food was always abundant. Birds generally develop a dominance hierarchy if food resources are limited. In the Blue-footed Booby (*Sula nebouxii*), the chicks completed for food and the largest and hungriest wins the food (Rodriguez-Girones et al. 1996). The effect of food deprivation in Kaka may induce development of a dominance hierarchy. This is a matter for further study. If this is shown to happen, then a dominance hierarchy in wild populations could indicate resource shortages. No dominance emerged after RP-P was installed in the cage with the other Kaka, after being re-caught. This suggests that there was no dominance hierarchy exhibited between the two groups either.

2.4.6 Summary

Post-release supplementary feeding programmes can be based on the consumption patterns of Kaka in captivity. Kaka in captivity showed preferences for different food groups. Because of this, management of captive and wild Kaka populations can be improved by the tailoring of feeding programmes to the most significant food groups consumed. This will increase the success of translocation programmes in the future. The provisioning of a

variety of food in the aviary increased individual experience, reduced neophobia, and improved the adaptability to the wild once released. Social adaptability as well as foraging efficiency was improved. The Kaka at Karori continued to develop social interactions after release, and the six birds formed a cohesive flock foraging together. The dispersal of the individual Kaka around the sanctuary as they foraged will show how well they adapted to the environment and will be the true test of survival. This is the subject of chapter 3.

CHAPTER 3:

Post-Release Dispersal and Survival

3.1 Introduction

Translocation is an important management tool for endangered species. The focus of conservation in New Zealand is the preservation of endangered species. Introduced mammals are an ongoing management issue and because of the continued threat to New Zealand's endangered species, management has usually involved removal of individuals to a protected offshore environment. Conservation now has to involve reintroduction of these species back to the mainland in order to re-establish ecosystem function, and to ensure the long-term survival of the species involved. The New Zealand Kaka is one such species.

Although not critically endangered, numbers of Kaka are in decline on the mainland and its survival is threatened. Kaka are good candidates for translocation. They fulfill most of the criteria that Wolf et al. (1996) suggest correlate with successful translocations: reintroduction within historic range, release into good habitat (managed sanctuaries), omnivory, and a gregarious temperament. The composition of and effect on the founder group must also be considered. Because the Kaka released at Karori were captive-reared, they have a known genetic origin and the genetic constitution of future translocated populations can be managed.

Genetic considerations are important when planning reintroductions as inbreeding depression can cause fertility problems. Jamieson and Ryan (2000) found that in Takahe (*Porphyrio hochstetteri*), inbreeding depression causes decreased egg fertility. New Zealand birds have an intrinsically low level of genetic diversity to begin with. The population is adapted to having genetic homogeneity, and can probably withstand a further reduction. However, a small population with a limited genetic diversity may result in a higher level of genetic homogeneity and this can lead to an altered population genetic structure and cause genetic drift. Translocation programme planners must consider the implications of the genetic make up of the future population

to maintain genetic diversity and increase the chance of population survival Conant (1998).

The ongoing survival of the population is an important measure of success (Wolf et al. 1998), and as Griffith et al. (1989) discussed, there is a wide range of success rates. They found a success rate of 46% for translocation of threatened endangered or sensitive species. The problem is that many endangered species are very sensitive to environmental change and challenges, and this does not make them resilient. Therefore, they are not the ideal translocation subjects. However, necessity means that management involves translocation of these animals. With each new translocation we increase our knowledge of the number of animals needed, the effect on genetic hetrozygosity, programme length required, the most effective release strategy (soft or hard release), and the effect on the founder population. All are important considerations for a successful reintroduction (Griffith et al. 1989).

The survival of captive-reared Kaka was demonstration by Berry's (1998) study. Her study only looked at nine birds, and information on releases of captive-reared Kaka is therefore limited. The release of Kaka at Karori held no guarantees. Karori is located in a major metropolitan area and the effect of this was an unknown. The survival of the Kaka was not certain and neither was fidelity of the Kaka to the release site at the sanctuary. Site fidelity was an important issue at Karori because of its urban location and because of its mainland situation and lack of physical barriers keeping the birds at the sanctuary. The Kaka to be released at Karori were particularly important to the sanctuary for financial reasons and this also increased the implications for the Kaka's survival and fidelity to the site. The sanctuary trust privately funded the translocation, maintenance of the birds in the aviary, and the ongoing post-release supplementary feeding. If the Kaka were lost, this would result in a loss of future earnings as the Kaka were expected to be a major visitor attraction.

3.1.1 Translocations

In New Zealand, translocations have been done as urgent essential last ditch measures to protect highly endangered species. The luxury of planning the long-term direction of protected areas was not an option. It is important to consider the theory behind reintroductions to ensure they are successful and the resulting ecosystems sustainable (Armstrong and McLean, 1995). Reintroductions as part of an ecological restoration programme can aid in the replacement and mitigation of damage to endangered species (Towns et al. 1997). The effect of the reintroduction on the habitat must be considered, as must the effect of removing an introduced species. The introduced species may have become a keystone species and removing it without consideration may adversely affect a sensitive native species, and may even lead to local extinctions of some species (Towns et al. 1997). The future use of the area and what future reintroductions are planned will affect the choices made now.

3.1.2 Mainland Islands

Many offshore island sanctuaries have been established to protect endangered species with some success. Tiritiri Matangi Island (Pryde 1997), and Kapiti Islands are examples of this. The establishment of such protected offshore sanctuaries is a last ditch attempt to protect some of our most endangered species. The next stage of this conservation strategy is to reintroduce endangered species back to the mainland. The establishment of mainland islands is becoming an important tool in this programme. The Department of Conservation has set up several of these sites over the country. They are managed in much the same way as offshore islands with ongoing control of introduced mammals and ecological restoration.

Karori Sanctuary is a mainland island located in a major metropolitan area so the dispersal of the birds out of the valley was of concern. Other birds had been successfully released at Karori, and hence the sanctuary has become an important tool for conservation in New Zealand. Several critically endangered species have all been successfully released and studied at Karori. Ecological restoration is important at Karori (Campbell-Hunt 2002),

and is an ongoing process. Attention was given to ecosystem areas and the species that could be reintroduced there in the future.

3.1.3 Key Issues to be addressed

Dispersal and survival were key issues for the release of the Kaka at the sanctuary due to the importance of the Kaka and the unique aspects of the sanctuary itself. Post-release dispersal and survival will be investigated in this chapter. The focus will be on survival, dispersal, and site fidelity. Socialisation will be important for future reproduction and the formation of a cohesive flock. Site fidelity is particularly important due to the urban location of the sanctuary. If the birds leave the sanctuary, they expose themselves to many dangers not encountered in forested areas. Kaka are good flyers and would be capable of reaching any location within Wellington city in a very short time. They could encounter dogs, cars, power lines, glass windows, people or any number of other dangers. If a male was lost that would be a loss of 50% of the males in the population similarly the loss of a female would reduce the females by 25%. With such a small founder group loss through mortality is significant, and monitoring dispersal therefore becomes important.

The aim of this study is to determine the success of releasing captive-reared Kaka into an urban environment. Berry's (1998) study showed that captive-reared Kaka have a high survival rate, and that high survival rate needs to be replicated at Karori if the release is to be a success. If the Kaka disperse out of the valley it will be necessary to determine where they go and why, and management steps can then be taken to ensure that they remain in the valley. The knowledge gained from the dispersal both within and outside the valley will give valuable insight into Kaka dispersal patterns, and the ecological reason for the dispersal. This will benefit future translocation plans and assist in keeping the released birds within the release site. I will also be observing and investigating social interactions between the individual birds. Social interactions will play an important part in the formation and cohesion of the flock, and may be important in the dispersal patterns observed. Determining

the way the flock structure develops can assist in determining if the two groups of Kaka can integrate. This will impact future releases.

3.2 Methods

3.2.1 The release

On August 23/08/2003, three Kaka were released. They were the three who on inspection had an acceptable transmitter attachment and whose harness had not slipped or chaffed the birds. On the 23/08/2002, RP-P, P-WY, and P-WO were all taken to the release site in cardboard pet carry boxes. The two females were siblings. Each box had some walnuts put in to keep the birds occupied. The release site was a grassy clearing beside the Kaka feeder, under the top Dam (later called the Dam Feeder). The release ceremony consisted of speeches, and a kaumatua said a karakia. The boxes were then placed on the ground, the lids opened and the birds released. Media covered the event. National radio ran an Item later that night at about 5.40 and the Dominion-Post and several local papers ran short stories. The feeder was chosen as the release site so the birds could orient toward to it and know were to find the supplementary food. The three remaining birds were moved into the former Auckland Kaka aviary. RP-P was re-caught in Island Bay and released back into the aviary on the 25/08/2002 with the three remaining birds.

The next release was on 06/09/2002. The two males, P-WB and RP-P, were released on 06/09/2002 (this was the second release for RP-P), in the grass clearing under the dam beside the feeder in the same way as before. There was another smaller release ceremony. The two Auckland females, RR-P and RW-P, were released on the 27/09/2002 and this was the final release. This release was done from the road overlooking the feeder beside the Tui Terrace (later referred to as the Tui Terrace feeder). I was invited to release one of the birds at this ceremony (Plate 3.1).

3.2.2 Tracking

The Kaka were monitored from release on 23/08/2002 to 31/08/2003. This gave data for an entire year. I monitored through August 2003 because the release was very late in August 2002. A TR4, Telonics Mesa, Arizona, USA portable receiver and hand held antenna was used to monitor signals. The same vantage points around the valley were used to scan each bird's signal to determine its location. The vantage points used were as follows: in front of the operations shed to cover the lower valley; the Tui Terrace lawn to cover the Western Scarp; beside the dam feeder to cover the beech track and Campbell street track area; and the top of the upper dam covering the southern reaches of the valley and the eastern side of the valley above the southern half of the Valley View track. I attempted to get a visual on, and observe each of the birds at least once a month and monitor location three times a week by receiving the transmitter frequency. Sometimes I was able to get a visual on an individual bird two to three times a week, and other times I would only get two transmitter locations in a month. Sanctuary staff and volunteers working in the sanctuary, and visiting members of the public all contributed the sightings and reports that have been included in my results.

Plate 3.1: The author releasing one of the Hamilton female Kaka from the road beside the Tui Terrace feeder.
The feeder is to the right of the frame. Another volunteer feeder in the background is releasing a second bird. Photo courtesy of Anala Miller.

3.3 Results

3.3.1 Dispersal

The Kaka generally remained in the sanctuary. Some regularly leave the valley but return within days (Table 3.3). Only one, RW-P, left the sanctuary and did not return, the last sighting of her in the valley being 10/01/2003. RP-P left the valley after release in September but returned in November. He was sighted again in the valley on 11/11/2002, and has remained since. RR-P left the valley on 03/11/2002. She went west through Makara Peak reserve and Karori Park. She returned to the valley on 08/01/2003. An un-banded wild Kaka appeared in the valley on 07/01/2002. He was left un-banded until 30/05/2003, when he was caught, banded, and fitted with a transmitter (Table 3.1), and has remained since. RP-P and P-WY nested and fledged four chicks in March 2003 (Table 3.2).

Table 3.1: Identity of wild male that arrived in the valley at the beginning of January 2003. His sex was determined by observing culmen length.

Kaka	Leg bands	Tx
Unbanded wild Male	OB-P	75

P-WY

After release on 23/08/2002, P-WY spent the first couple of days sitting very quietly near the release site (Table 3.3, Plate 3.2). She then got bolder and started venturing further afield going up the western scarp near the swamp track, W Line, and around the beech stream. She and P-WO moved together up toward the top of the Campbell Street Track, but she still spent most of the time near the release site. P-WY dispersed further in October and November. She was often on the western scarp near W Line with P-WO, and further along the scarp above the Tui Terrace with P-WB. RP-P started courting her, and as her courtship with RP-P progressed she spent more time at the Tui Terrace feeder (feeder closest to nest box one), and near nest box one on the eastern scarp around XW Line. There was a marked increase in observations

for her near nest box one as she starting nesting in December and February. She continued to remain in the nest area until May when the chicks gained independence. From April on she was frequently seen on the western scarp with them. On the 11/06/2003, she lost her transmitter; and it was located on the western scarp.

P-WO

In the first couple of days after release P-WO stayed close to the dam feeder (Table 3.3, Plate 3.2). She then moved further from the release site and up to the western scarp. In October, she was seen with P-WY near the Beech stream, and on the western scarp. Observations of her at the Dam feeder in November, January and February were mostly near the feeder dam area. In February after OB-P appeared, P-WO tried to get close to him but was rebutted. He tried to chase her off initially, but then started to accept her and they started to forage and mutually preen each other regularly. She started to exhibit nesting behaviour, and on 24/01/2002, she was observed investigating nest boxes three and four. They were seen mating on 12/02/2003. In June and July P-WO ventured up to the Fuchsia track area and over the eastern fence into Denton Park.

P-WB

P-WB was released on 06/09/2002 (Table 3.3, Plate 3.2). As with P-WY and P-WO, P-WB spent the first few days after release near the release site. He also started to venture further as time went on, and moved up and along the western scarp. In October he was seen taking Blackbirds (*Turdus merula*) eggs out of a nest and dropping each in turn on the ground, demolishing the nest. Observers said his actions looked deliberate. He was most frequently located near the dam feeder area up to and during February. Then his visits to the dam area grew less frequent, and in January he went over the fence to Denton Park. From March, he spent most of his time at the north end of the valley on the western scarp, above the lower Dam Lake. His transmitter harness's weak point broke on 27/03/2003, and the transmitter was left dangling around his neck. Staff were unable to catch him and remove it and it is still hanging around his neck. It does not prevent him foraging, and is not

endangering his life. In March, he went over the north end fence and continued along the scarp, and was seen in Birdwood on two occasions. In July I saw him flying across the upper lake, the transmitter still dangling from his neck. In July he was seen south of T Line, on the western scarp with several other Kaka. In August he was seen on the Round-the-Lake Track on the eastern side of the lake.

RP-P

Soon after initial release on 23/08/2003, RP-P moved away from the feeder after a short time of orientation (Table 3.3, Plate 3.2). By that afternoon he had flown off down the valley. On the third day after release 25/08/2002 he was located in Island Bay in the garden of Mr Peter Bush. He was caught and reinstalled in the aviary with the three remaining Kaka. After his second release on 06/09/2002, he immediately flew off east again toward Island Bay. His transmitter signal was received in a couple of parks in Island Bay. On 11/11/2002, he returned to the valley and started courting P-WY. They started nesting from December to April, and so he was seen at the nest site regularly. He started landing on my head and preening my hair in December; and he eventually did this regularly to other staff and visitors. His transmitter failed on the 16/01/2003. It was replaced on 15/05/2003 after he was caught in a mist net. His weight at that time was 480 g. He had a tendency to range along the eastern scarp, whereas the other birds were often found on the western scarp. He was seen near the Union Mine track, the Morning Star Track, and above the Valley View Track regularly. He liked foraging for invertebrates in the abundant pine logs there. Once the chicks had fledged, he moved around with them up the eastern scarp and then across to the western scarp.

RR-P

When first released on 27/09/2002 she flew back over our heads to the western bank near X Line (Table 3.3, Plate 3.2). Within days of release, she had moved to the western scarp, up near the Fuchsia Track. I saw her twice near T and S Lines in October. She moved up the slope then south along the fence line, and I saw her on 01/11/2002 on Q Line near the fence. She left the valley after that and I tracked her as she continued moving west to Karori

Park, and then along Makara road until her trail was lost in early December. She reappeared in the valley on 08/01/2003. Soon after she returned, she was seen with an un-banded male (OB-P) who had appeared. This lasted only a week or two before he paired up with P-WO. She spent more time with P-WB after that. She frequented the eastern scarp with P-WB, but was located on the western scarp more regularly. She was seen in Denton Park with several other birds in June.

RW-P

After release on 27/09/2002, RW-P immediately left the valley (Table 3.3, Plate 3.2). She was located at Wright's Hill reserve just over the Western fence 11/11/2002, and was apparently seen at the dam feeder twice in November. I did not receive a transmitter signal for her on these days, but I did receive signals for her in the valley on other days in November. In December, I tracked her to the nearby Makara Peak mountain bike reserve after a report was received that a Kaka had been seen on a track there. On Boxing Day, I received a signal for her coming from Denton Park, so she had crossed back over the valley from the west and was heading east. On the 29/12/2002 she flew into the window of a house in Highbury road, and was stunned. The homeowners took her inside then phoned the sanctuary. She regained her senses, climbed out of a louver window in their home and flew away. Only one other confirmed sighting was ever made of her, and that was in January 2003 when a staff member saw her at the feeder.

OB-P

After OB-P arrived, he was most frequently seen in area around the dam feeder (Table 3.3, Plate 3.2). He was seen at the nest site with the family (P-WY, RP-P and the chicks) on several occasions, and was seen soliciting food from both P-WY and RP-P. He would chase the chicks through the trees trying to touch and preen them. OB-P was caught on 30/05/2003 and fitted with a transmitter, and banded. In the first few months after arrival, he frequented the area around W Line near the Beech Track. He visited Denton Park with the other birds in July, and frequented the western scarp and dam

feeder. He was seen sitting very close to P-WO up above the swamp track near V Line in August.

3.3.2 Dispersal to locations outside the sanctuary.

There were anecdotal reports of Kaka being seen in Otari, Wiltons Bush, the Botanical gardens 3km away, Mount KauKau, and even Catchpool near Wainuiomata. These were unconfirmed.

3.3.3 Distribution and activity of the chicks over time.

Table 3.2: The successfully fledged chicks, identifying leg bands and transmitter frequency.

Chick	Transmitter Frequency
P-YY	77
P-YR	73
P-YB	71 and 89 after 14/07/03

For the first few weeks after fledging, all the chicks including P-YY stayed close to the nest box area (Table 3.3, Plate 3.2). They gradually started moving up the slope of the eastern scarp parallel with W Line until they reached the Valley View Track. They stayed up there a couple of days and then moved all the way across to the western scarp. In May, their mother started to show the chicks how to use the Tui Terrace feeder. The chicks started to spend more time on the western scarp from May. P-YR was often found sitting alone on the ridge above the Beech stream, on the south side of the Beech Track. They were often seen back at the area just north of the start of the Beech Track, below were the nest site was. This area seemed to become home base for them. From June the chicks started to go further, and P-YY went with several of the other adults out of the valley to Denton Park. In July the chicks went south up the valley and foraged with several adults near OP Line. P-YB was caught and a new transmitter fitted as her harness had broken on 14/07/2003

	August 2002	September	October	November	December	January	February	March	April	May	June	July	August	Total
E scarp N of UM Tk				4	1		2			2				9
E scarp south of UM tk				2		2	1	1	6	4	2	2		20
Fan tail tk												3		3
Nest area				1	12	17	17	34	13	11	4	1	1	111
On nest						14	11	9						34
N of Beech		3	3	6		3	1			1	5	1	5	28
Beech TK		1			1		1		11	2	7	6	6	35
Beech Stream		3				3			1			1	2	10
Dam	6	17	9	26	8	14	29	12	9	4	2	14	2	152
Feeder D		5	2	25	1	32	8	19	7	3	6	7	1	116
T Line E side													2	2
Upper Lake and Aviary		1										1		2
South of Q Line W scarp				1								7		8
ST Line west side			2	1					1		1	2		7
Campbell St Tk	2	2	5			1		3	2	1				16
W scarp W Line		5	13		2	1	4	1	29	2	3	1	1	62
Swamp		2	3		4	4	11	5	3	1		1	2	36
TM tk				1			3	1	3	6	5	5	16	40
W above Tui			2	1					6	5	2	1	1	18
Tui				1	3		1		3	6	1		4	19
Feeder T				5	17	1	14	5	2	9	3	4	3	63
HH bot val								1	2	4				7
Rugby pk			1											1
Highbury Pk					1									1
Denton Pk					1	1					7			9
Karori Park					1									1
Makara Pk					3									3
Makara Rd					2									2
Wrights hill				1										1
Bridwood								1	1					2

Table 3.3: The frequency of observations in each area each month.

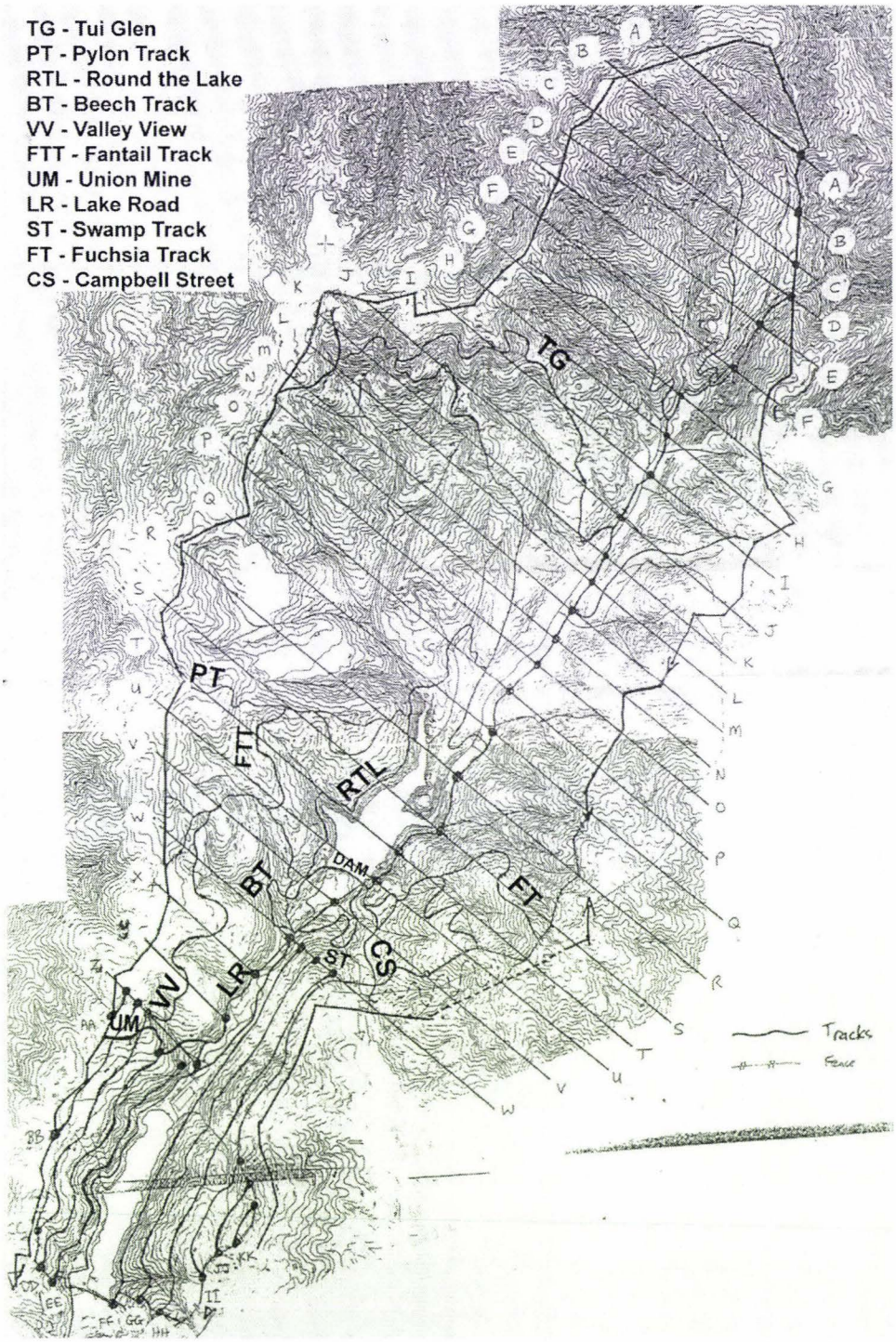


Plate 3.2: Map of Karori Wildlife Sanctuary.

Walking tracks as discussed in the text are marked.

3.4 Discussion

3.4.1 Survival rate

The survival of the Kaka post-release was 100% for the first five months. After December 2002, the fate of RW-P is unknown. The five remaining captive-reared Kaka and the wild un-banded Kaka arrival were still alive at the end of August 2003. The survival rate of the original Kaka released at Karori post December is therefore at least 83% for the first year. The findings in this study concur with Berry's (1998) findings, that captive-reared Kaka are able to establish a new population and have a high survival rate after release. In this study and Berry's (1998) study, the fate of the Kaka that left the study arrears is not known. They have effectively been lost from the population. Berry (1998) calculated an annual survival rate of 78% for the release at Mount Bruce. With such a small sample size, it is not possible to determine if there is a statistical difference between the survival rates of the Kaka at Mount Bruce and those at Karori.

Compared to other parrot releases, this is a high survival rate. Collazo et al. (2003) reported a survival rate of 30% and 29%, one year after releases of captive-reared Hispaniolan Parrots (*Amazona ventralis*) in 1997 and 1998 respectively. They identified lack for forage as an important factor in the survival and dispersal out of the release site area for the parrots. This supported the continuation of supplementary feeding at Karori. The previous insights into the Kaka's ability to adapt to the natural foods was important in this respect also, if Kaka would or could not take the abundant natural foods available in the sanctuary the success of the release and any future releases could be adversely effected. Syndel et al. (1994) sighted mixed results in the release of Thick-billed Parrots (*Rhynchopsitta pachyrhyncha*). The reason for this is attributed to deficits in foraging, socialisation, and predation rates. Lindsey et al. (1994) found that the survival of Puerto Rican parrots (*Amazona vittata*) was between 43% and 100% following release. Predation was the main cause of mortality in this population. If captive-reared Kaka releases can

provide the same consistently high rates of survival in the future, using captive-reared releases will be a successful and viable management tool.

The two main factors affecting survival in the above studies were ineffective foraging, leading to starvation, and predation. The supplementary feeding program at Karori was designed to prevent starvation, and eliminate it as an issue. There is no predation within Karori, so the survival rate at the sanctuary should be higher then non-predator managed areas. The main threat the Kaka at Karori had to face was the proximity of the city. Karori is a relatively small area considering the flying capabilities of Kaka, and it was quite conceivable that the Kaka would leave the sanctuary at some stage. The dangers that they could encounter in the city are vastly different and more numerous than those in the bush. This made the issue of site fidelity important.

3.4.2 Increasing site fidelity

In an effort to encourage site fidelity the Kaka were kept in the aviary for approximately three months prior to release. Bright and Morris (1994) found that captive-reared dormice (*Muscardinus avellanarius*) remained closer to the release site than wild-caught ones. They proposed that captive caught mice were slower to adapt to a new environment. This may be due to captive-reared animals having had less exposure to new experiences than their wild caught counter parts and therefore being more neo-phobic. It could also be due to captive-reared animals being more habituated to supplementary food and finding natural foods unfamiliar and so they stay close to supplementary feed sources. This can also work in reverse with wild-caught animals being unfamiliar with supplementary food and dispersing to locate natural occurring food sources. The wild-caught Kaka at Mount Bruce were only held in captivity for two weeks, and a longer period may have increased site fidelity in that group (Berry 1998). Berry (1998) found that captive-reared Kaka remained closer to the study site than wild-caught Kaka. The Kaka at Karori were captive-reared, and as such would have been predisposed to remain close to the study area. This is in fact what was noted, however we had no wild-caught birds to compare site fidelity statistics to.

Familiarity with the release site may be an important factor in increasing site fidelity, but familiarization with other individuals may also be important. Socialisation may be more important in the parrot family than in other birds, and so the presence of their species in the release site may be important for them. Island birds are more social than forest-dwelling continental parrots (Gilardi and Munn 1998), so socialisation may be particularly important for Kaka. The post-release behaviour of seeking out contact with their own species emphasizes the importance of this. P-WY visited the aviary while RP-P and the Auckland Kaka were still in it. In addition, after three new Kaka from Otorohanga arrived at Karori in June 2003, the Hamilton and Auckland Kaka were frequently seen near the aviary communicating with them. There are no other wild Kaka in the Wellington region, and RP-P and RR-P may have returned to re-establish contact with their siblings and species because of this. Armstrong and Craig (1995) found no evidence that with Saddleback (*Philesturnus carunculatus*) familiarity with other released birds increased the success of translocations. However, Saddlebacks are not generally social birds and Armstrong and Craig pointed out that the result may have been different with different species. The fact that Kaka are social birds, and the fact that flocking was advantageous in achieving site fidelity may be a consideration for future releases. Other things were also done to increase site fidelity.

The method of release can be used to encourage site fidelity. The first two Kaka releases were near the dam. It was hoped that the birds would be able to orientate to a feeder and use it as a landmark. Showing the Kaka where to find the feeders also ensured they knew where to find the food, and would be encouraged to stay. Knowing where to find food if needed improved the probability of survival. The third release was from the road above the Tui Terrace feeder. This was done so that these birds might use the second feeder. This would minimize the competition on the dam feeder and distribute use between the two feeders. However, on release RW-P and RR-P flew back over our heads and toward the eastern scarp. They may not have seen the feeder, and may not have been able to orientate to it. This may have

contributed to them instantly moving off, venturing further than the other birds did on release and eventually leaving the sanctuary.

The provisioning of supplementary food may have helped establish site fidelity. Mount Bruce also provided supplementary feed for their released Kaka (Berry 1998), and this may have resulted in the site fidelity that was observed. Supplementary feed may be especially important in increasing site fidelity with the captive-reared Kaka. The captive-reared birds are more familiar with the supplementary food than with natural food, and may have had a higher site fidelity level because they remained close to the feed stations. The Kaka at Karori seemed to base themselves around the dam feeder area. They often returned to feed and interacted socially there. They would sit at the feeder calling to attract the attention of other Kaka and seemed to use the feeder as a focal point. This may have been due to the feeder being a commonly used location due to the available food, or the fact the feeder could be a common landmark all the Kaka used as a reference point.

Supplementary feeding provides a constant food source that the Kaka utilise all year, and they may remain in close proximity to it to benefit from this. Brewer and Harrison's (1975) study suggests that sedentary birds focus on winter food supply rather than spring food supply when choosing a territory. This would suggest that birds select their permanent territory sites in locations where food supply is assured during months when food supply is most limited. Kaka may choose to stay near a supplementary food supply for the same reason, i.e. to assure themselves of a constant food supply during winter. This is probably more important for captive-reared Kaka as they are more familiar with supplementary foods than natural foods. There are other reasons that Kaka may chose to stay near feeders e.g. social reasons and lack of experience dispersing.

If the presence of the feeder were a factor in increased site fidelity, then a high level of feeder use would be seen in birds with a high level of site fidelity. This was observed in the Mount Bruce Kaka (Berry 1998). The wild-caught

Kaka used the feeder less, and had a greater dispersal distance than the captive-reared Kaka. However, this may have been due to the captive-reared Kaka having a greater familiarity with the supplementary food than the wild-caught birds. At Karori, two of the Kaka that dispersed out of the valley returned. Of these, one had the highest use of the feeder and the other the lowest (figure 4.1). The high use of the feeder may be the result of high site fidelity, not the cause.

3.4.3 Observed dispersal

At Karori, all the Hamilton Kaka dispersed out of the valley, despite being captive-reared and having no experience of moving large distances and limited experience with natural foods. The Auckland Kaka all remained at the sanctuary after release. Berry (1998) found that the four captive-reared Kaka did not go more than 1km from the release site, whereas the wild caught Kaka tended to range further (200m in June, 500m in September, 700m in October). The dispersal pattern of the wild caught Kaka at Mount Bruce tended to parallel that of the Hamilton Kaka at Karori, and the captive-reared Kaka at Mount Bruce tended to match the dispersal pattern of the Auckland Kaka. The Kaka that did disperse out of the sanctuary tended to do so in the first six months, after which they appeared to settle and stay at the sanctuary. The Kaka at Mount Bruce increased dispersal distance over time. However, the Kaka at Karori dispersed to more locations around the valley as time went on, but overall dispersal distance decreased. All left the valley more frequently, but dispersal distance was short. Dispersal out of the valley was also for a much shorter timeframe- days, not months as before. Often they only went into the next valley or a bit north of the valley to Birdwood, and possibly Otari gardens. Long-term dispersal patterns at Mount Bruce are not known as Berry's (1998) study only covered six months.

My observations point to another factor influencing dispersal for Kaka other than origin (captive vs. wild). The disposition of the different sibling groups may have been important. It may have been due to handling differences by the keepers at Auckland and Hamilton Zoos. Handlers interacting with the

Kaka more regularly and providing them with stimulation may have precipitated dispersal in the Hamilton Kaka. If this is the case, hands-off management of captive parrots may need to be reconsidered, particularly if the birds will be used in a reintroduction plan. Aengus and Millam et al. (1999) showed that handling by humans increases tameness by decreasing the fear response and increases adaptation to captivity in Orange-winged Amazon chicks (*Amazona amazonica*). Decreased levels of human habituation may result in increased neo-phobia and a decrease propensity to disperse to unfamiliar habitats. The Auckland group of Kaka may have received less handling than the Hamilton group making them more neo-phobic and more likely to remain closer to the release site. Meehan and Mench (2002) studied Orange-winged Amazon parrots (*Amazona amazonica*) and found that environmental enrichment reduced fear of novel objects and promoted exploration. Parrots raised in enriched environments showed less fear when introduced to novel situations and were therefore better able to adjust and they started to explore their environment more readily then parrots raised in sterile surrounds. This illustrates the importance of behaviour enrichment for captive habitats, and is particularly significant for captive animals involved in release programmes. Having a reduced level of neo-phobia and propensity to explore the environment will improve the success of the release. This should be considered in any release by improving the ability for the birds to interact and integrate into their new environment.

Berry (1998) suggests that the young birds are more adaptable than older ones. The release at Mount Bruce and Karori were both with young birds, and this may have increased the survival of the Kaka. The fact that the Kaka at Karori were two to three months older then the birds released at Mount Bruce may have caused the difference in dispersal rates seen between the Kaka at Karori and the captive-reared Kaka at Mount Bruce. Only a second release of nine-month old Kaka would be able to determine whether age was the only factor, or whether the differences in behaviour are based more on clutch differences. As the two groups of Kaka at Karori were similar in age and still exhibited differences in dispersal, it is not likely to be an age issue.

The distance to place of origin may have been another factor in the Kaka site fidelity. Both Hamilton and Auckland Zoos are beyond Kaka flight distance. Kapiti Island, however, is within flight distance to Mount Bruce. Berry (1998) had several Kaka make for the Kapiti coast. The Karori birds that left the valley went in random directions. One went east and two Kaka went west. Of the two that went west one returned, the other permanently left the sanctuary and was last seen heading east. The fact that the Karori Kaka could not return to their site of origin may have increased site fidelity.

3.4.4 Implications and the future

These findings suggest that Kaka dispersal distance is more likely to be an individual personality trait, rather than something gained from habituation to the wild. Captive reared Kaka are capable of surviving, and are not disadvantaged by lack of experience with the wild environments. The fate of RW-P was not determined, so the results are more an estimation of site fidelity rather than survival.

The presence of predation may impact any future Kaka release. Karori is predator free and Mount Bruce is heavily predator managed. No test has been conducted on the survival of released Kaka into a non predator-managed area. The released Kaka may not directly suffer predation but any nesting attempts may not succeed in the presence of predators so the population would not be sustainable long-term. Captive-reared Kaka may be able to adapt to the new environment with no problems but may still be very predator naive. This needs to be considered when planning future releases.

Berry (1994) suggested that the measure of success for translocations is when the animals stay in the release site, integrate into the new habitat, and survive long enough to reproduce and replace themselves. I take the meaning of 'integrate into the habitat' as being able to survive in the new environment with no support from people. This is, of course, the ideal situation but is not possible for reintroductions to the New Zealand Mainland. Predator control will always be a basic requirement of any native species

management in mainland New Zealand. The Kaka at Karori are reliant on the management of the sanctuary, so are not free from human intervention in the purest sense. However, they have managed to adapt and thrive in the new habitat. They have reproduced and the population size has increased, so meet the above requirements for a successful translocation. This study and Berry's (1998) study have shown that captive-reared Kaka can be released into a protected environment, and survive despite the proximity of a major city. They show a high level of site fidelity and stay near the release site.

The Kaka did leave the valley to forage. I was not able to determine whether the Kaka were leaving the valley in search of a particular food source. When P-WB went to Birdwood he was seen to forage on flowering exotics. This was most likely to have been opportunistic. When the Kaka were seen in Denton Park they forged on the same species that they foraged on while in the sanctuary. They must have left the sanctuary for another reason. As they did not seem to be leaving for a particular food source, and did not go far from the sanctuary, there was no issue with site fidelity being reduced by habitat suitability. They were not leaving because of deficiencies in resources at the sanctuary. The Kaka have developed a high level of site fidelity and are likely to remain at the sanctuary long term now. Site fidelity seems to have increased over time for any number of reasons, supplementary feeding, socialisation, and site familiarity. These factors continue to be relevant to Kaka reintroduction locations, and will play a part in future management. Karori held particular challenges for site fidelity, but this study showed that a high level of site fidelity can be achieved, and so the translocation was successful.

3.4.5 Summary

The proximity of the city did not reduce the survival or dispersal rates. The Kaka may have visited locations in the city (anecdotal reports), but probably only visited Denton Park (the next valley east of the sanctuary), Birdwood, and Makara Peak. When the Kaka did leave the sanctuary, they confined themselves to bush areas and did not expose themselves to the dangers of the city. The only exception was RW-P who flew into a window, and RP-P in

Island Bay when first released. The sanctuary location meant that the sanctuary is well serviced, and well utilised by the public. This provided revenue for the sanctuary as the publicity around the Kaka release drew visitors. However, the Kaka did have to cope with being highly visible to visitors. They did not move out of the most popular areas for visitors, and could easily have found secluded locations if they had wanted to do so. The feeders were very public and so Kaka had to run the gauntlet of visitors to get food. This did not seem to affect them, and they seemed to be oblivious to spectators. If this did affect behaviour and use of the feeder, it would be evident in feeder use, foraging patterns and activity budgets. This will be investigated in the next chapter.

CHAPTER 4:

Post-Release Behaviour of Kaka

4.1 Introduction

The behaviour of the Kaka was monitored post-release along with their dispersal. Post-release behaviour was just as important as dispersal for the survival of the Kaka – individually, and as a population. They needed to forage effectively for natural foods and develop social interactions so that future reproduction was possible. The establishment of a self-sustaining population is the basic measure of a reintroduction success (Griffith et al. 1989). If this is to happen, integration into the environment is important, as the captive-reared Kaka must be able to adapt to a wild habitat. Berry's (1998) study showed that captive-reared Kaka can forage effectively for natural foods, but do so to a lesser degree than wild-caught Kaka. From observations while in captivity the Kaka at Karori showed they have instinctive behaviours that will allow them to forage on natural foods. Although they will be supplied with supplementary food on an ongoing basis, the supplementary food will not meet all their dietary needs and they will have to forage on natural foods to obtain all nutritional requirements. Determining how the Kaka adapt to their new habitat will guide the management of future releases of captive-reared Kaka.

4.1.1 Foraging behaviour

Berry (1998) found that captive-reared Kaka survived for at least 6 months after their release into the wild, and that they were able to forage effectively for themselves. She found that the captive-reared Kaka were more dependent on supplementary food than their wild-caught counterparts. At Karori, only a minimum diet would be provided post-release and the Kaka's ability to forage on natural foods would be important. The way the Kaka disperse around the valley and use the food resources available will show how good the Kaka were at adapting to the wild environment and how they used available food resources. The Kaka need to respond to temporal changes in food supply as well as adapting to spatial difference in food abundance, just as any animal in the wild must. They must learn where, when, and how to find food. Renton (2001) found that the Lilac-crowned parrot (*Amazona finschi*) showed a significant variability in

resource use both temporally and spatially that matched the shifting availability of resources. The Kaka at Karori will also need to match resource consumption with availability if they are to forage effectively on natural food.

4.1.2 Suitability of the habitat

The integration of the Kaka into their new habitat is dependent on their finding food effectively, but the environment must be able to provide that food. The habitat must be suitable for the species to be released there. Cayford and Percival (1992) found that the survival of Barn Owls is jeopardised if they are not released into suitable habitat. The habitat at the sanctuary must be able to support the Kaka. Their dispersal and foraging patterns will show if this is the case. Every environment has a functioning trophic structure into which a species must integrate. Returning the ecosystem to as close to pre human disturbance state is the ideal situation. This way a balanced functioning trophic system can be achieved, this will insure stability of the habitat long term and success of the release. For this reason it is important that that if possible a species should be translocated to an area where it was historically present (Griffith et al. 1989). At Karori, the habitat is regenerating forest, and as such may not provide the Kaka with adequate food. If this is the case, the successional stage of the forest may become an issue for future releases.

Restoration programmes can then be geared toward providing the requirements for future reintroductions. However, if the sanctuary successfully supports the released Kaka, then this will also provide valuable information for resource management and reintroductions in the future. Either way, restoration programmes in the future will benefit from information on habitat use. Future restoration programmes will be better able to manage the ecosystem to provision protected and endangered species. This is an important issue, particularly in New Zealand where offshore islands with limited resources are the focus of most protected species recovery plans (Pryde 1997). Re-vegetation to restore to historical condition or with a view to provision a translocated species is a common place practice in New Zealand, although it is generally beneficial for the released species the practice still alters the existing ecosystem. These are all

considerations for any management plans. This was true for the sanctuary also. The use of the area surrounding the sanctuary is particularly important because of the proximity of the city. The reasons the Kaka might leave the valley will impact future management of the valley. If food resources are being obtained outside the valley by the Kaka, then future planting programmes at the sanctuary can be modified to meet this need.

4.1.3 Socialisation

The socialisation in the Kaka is important for the success of the reintroduction at Karori in order to ensure the long-term survival of the population. Interaction between the two groups (from Auckland Zoo and Hamilton Zoo) would indicate whether pair bonding were possible in the future, and is important for the formation of a cohesive social unit. Parrots are flock birds and flocking in parrots provides stimulation, reproductive opportunities, protection, and allows a group to share individual knowledge of resources in the area. Captive-reared Thick-billed Parrots (*Rhynchopsitta pachyrhyncha*) have poor survival rates if they are deficient in socialisation skills (Syndel et al. 1994). The social stimulation is important for Kaka as chicks take months to gain independence, and the family group remains cohesive long-term after that.

As captive-reared birds, the ability to adjust and survive in the wild could be affected by the absence of parents or experienced birds to learn from. At Mount Bruce, the captive-reared had wild-caught birds to fill this function, but at Karori they did not. The development of a social structure in captive-reared Kaka may have been impaired, and so the ability to function in the wild is decreased. This results in decreased foraging efficiency and higher predation rates (Syndel et al. 1994). Lindsey et al. (1991) recommend that in order to allow integration into the flock and avoid problems associated with deficient socialisation, captive-reared Puerto Rican parrots (*Amazona vittata*) should be five months old when released. This is the age when the parrots most successfully integrate into the flock. Successful flock integration increases site fidelity, and this is particularly important at Karori.

The formation of a cohesive flock may promote foraging effectiveness and site fidelity by sharing experiences and increasing social bonding. Because the two groups of Kaka have different origins, and there are no resident Kaka at Karori, a new culture may develop unique to Karori. It may be a combination of the two groups' existing communication and foraging habits, or they may develop new habits to match the new environment at the sanctuary and develop an entirely new culture.

The development of a unique call dialect may indicate the development of a new culture. Communication among the Kaka is essential to develop the social interactions that Kaka need for flock cohesion. Baker (2000) studied the vocalisations of Ringneck Parrots (Barnardius zonarius), and found that call variations distinguished cultural difference between populations and were an important part of pair bonding. As captive-reared birds, the Kaka may have limited experience of the range of calls needed for life in the wild and may develop their own calls. Roberts et al. (2001) and Brauth et al. (2002) both studied the parrot brain physiology and showed that the parrot brain is hard-wired to learn complex communication patterns. Both iron distribution and the expression of an early gene protein in the Budgerigar (*Melopsittacus undulatus*) indicated the emphasis on the processing of auditory and visual stimuli. This indicates the importance of learning and processing these cues for social functioning in parrots.

This chapter will look at two main areas; the temporal patterns in natural foraging and the social interactions within and between the two groups of Kaka. The foraging activity will be recorded and will show whether temporal patterns emerged, and how Kaka used each food type. I will be investigating any evidence of possible pair bonding, the significance of social behaviour, and in particular the emergence of any learning exchanges and cultural interactions. Any particularly close involvement between Kaka will show whether they preferentially spend more time with some individuals over others. Community development is another aspect of population establishment that will be investigated. Information on social ecology and foraging ecology will allow enhancement of management, and improve the success of releases in the future.

The ability of captive-reared Kaka to integrate socially, and into the environment will impact future management. Culture development will be evident by an emerging social structure (hierarchy), and if there is any information exchange between the Kaka. Information exchange could be the teaching of how to forage at the feeder or on natural foods, or the learning of a call specific to Karori.

4.2 Methods

Over the period of the study, 28/08/02 to 31/08/03, the Kaka were monitored and behavioural data collected. Individual birds were located using telemetry. Observations were conducted between 08:30 to 17:30 – the hours of business for the sanctuary. I tried to observe the daily flocking at dusk (about 17:00), but this was not always possible. I was also not able to get observations after 18.00 as the sanctuary was closed and safety protocols would not permit this. On one occasion, I was able to get an observation at 20:00 due to attendance at a social function after closing hours. I tried to get observations for each bird at least once a month. Observations were also obtained from staff and visitors. Some birds were observed more frequently than others because they were nesting, or had a transmitter that was incorrectly attached and were being monitored more closely. I chose which Kaka to track based on a number of things including: when a bird was last seen. How close it was to Dam feeder. If it was in the presence of other Kaka. Whether that birds were breeding or not.

The Kaka were monitored continuously from the time they were first sighted until they departed to a new location (more than approximately 50 m away). Behaviour was recorded over the observation period, and when behaviour changed the new behaviour was recorded. Any other bird observed with the one I was targeting was also monitored continuously. I recorded date, time, activity category, interaction with other individuals, height within the canopy, and the species of tree occupied and foraged on.

Feeding: The observation on feeding were categorised as

1. At feeder
2. Feeding on sap or wood pith
3. Feeding on invertebrates
4. Feeding on fruits or nectar
5. Feeding on other e.g. epiphytes and mosses

Activity of bird other than feeding: The categories were

1. Perching quietly including scratching
2. Preening
3. Climbing actively through branches
4. Calling and interaction with other Kaka
5. Sleeping - including stretching.
6. Other e.g. playing, sitting on nest, or on observer's head.

Level in the Canopy: The categories were

1. Top of canopy
2. Mid level
3. Low to the ground in the under-storey
4. At ground level
5. Foraging on the edge of a clearing or track

Data on the tree species and type of food obtained was correlated with the data on what food was being obtained, e.g. fruit, insects, sap etc. I assessed whether use of tree species changed over time, and the use of tree species in different regions of the sanctuary. The general use of the supplementary food was obtained by observations of the Kaka using the feeders. Once released the supplementary diet fed was very basic (walnuts, carrot, sunflower and wheat seed mix, and dates). The majority of the time the food was totally consumed and proved to be of little value for statistical inference. In addition, the Kaka were not the only birds consuming the food, so the data would not give an accurate impression of Kaka consumption patterns.

4.3 Results

4.3.1 Natural foraging patterns

Overall, most of the foraging was during the winter months with reduced foraging activity in summer. The favoured food species were Coprosma species, Five finger/ Puahou (*Pseudopanax arboreus*) and Mahoe (*Melicytus ramiflorus*), 19.5%, 16%, and 10.1% respectively (Table 4.1). The Kaka had a wide range of foods but tended to use same species for the same food e.g. Pine (*Pinus radiata*) for invertebrates, and Coprosma, Five finger and Mahoe for tapping sap. Most of the foraging on natural foods was done in February, March and April. The chicks used Dogwood fruit (*Cornus florida*) in March and April, and graduated from this fruit on to native plant saps and fruits (Table 4.2). After the Kaka were released they used the flowers of the Fuchsia (*Fuchsia excorticata*) and its fruits in January and February. There was a peak in Mahoe use in November when it flowered and again in March and April when it fruited. Supplejack (*Ripogonum scandens*) was taken mostly in February for its fruits.

Kaka tapped sap from trees as well as stripping bark from branches. When tapping trees the Kaka would use a different type of cut for each different species. Five finger trees were tapped with a long slit and the bark peeled back, while coprosma were tapped using an oval hole with the bark chiselled away. The methods may have been adapted to each species as result of the different bark, wood or sap characteristics. Sap tapping was usually done on branches and trunks over 5cm in diameter. Anything smaller was usually stripped of bark, and the sap licked off the exposed cambium underneath.

Table 4.1: Individual observations of foraging on each tree species each month, and the percentage of total observations for each tree species.
Observations were recorded for each individual Kaka observed in a tree while it remained in that tree. If a Kaka left a tree and returned it was recorded as a new observation, if two or more Kaka were present in the same tree each Kaka was recorded as a different observation.

Trees	August	Septemb	October	Novemb	Decemb	January	February	March	April	May	June	July	August	Total % time spent
Beech	2			1					1		1		1	2.1
Nothofagus species														
Coprosma	3	8	4	3		2	7	4	9	2	3	7	4	19.5
Coprosma species														
Cypress			1				1	1	1				1	1.7
Cupressacea														
Dogwood		2				1	2	4	8	2	1	2		7.7
Cornus florida														
Five finger/ Puahou	1	8	4	3	1		5	7	7	3	5	3	1	16.7
Pseudopanax arboreus														
Fuchsia/ Kutuku		1	5	1		2	4	3	1	1		2	2	7.7
Fuchsia excorticata														
Gorse										1				0.3
Ulex europaeus														
Hangehange	1													0.3
Geniostoma rupestra														
Haumakaroa		1												0.3
Pseudopanax simplex														
Hinau								1						0.3
Elaeocarpus dentatus														
Holly								1						0.3
Aquifoliaceae														
Karaka			1						2	4	2	1		3.5
Corynocarpus laevigatus														
Kawakawa		1						3	3		1			2.8
Macropiper excelsum														
Kohekohe									1	1	1	1	2	2.1
Dysoxylum spectabile														
Koromeko							1	1				2		1.4
Hebe parviflora														
Kowhai			3	1					1					1.7
Sophora tetraptera														
Lacebark/ Houhere												1		0.3
Hoheria populnea														
Lancewood/ Horoeka										1				0.3
Pseudopanax crassifolius														
Mahoe		1		5	1		4	6	6	3	1	1	1	10.1
Melicytus ramiflorus														
Makomako													1	0.3
Aristotelia serrata														
Mapou/ Matipo									4					1.4
Myrsine australis														
Moss										1				0.3
(Unknown species)														
Pate									1					0.3
Schefflera digitata														
Pigeonwood						1	2	4			1			2.8
Hedycarya arborea														
Pine			1	2		1	1		2		1	1		3.1
Pinus radiata														
Pokaka	1											1		0.7
Elaeocarpus hookerianus														
Rangiora			2					1	2		1	1	1	2.8
Brachyglottis repanda														
Rewarewa										1	1			0.7
Knightia excelsa														
Supple Jack		1				2	5	1	1	2			1	4.5
Ripogonum scandens														
Totara				1			1	1						1.0
Podocarpus totara														
Tree fern			1					2				1	3	2.4
Dicksonia spp														
Total monthly observations	8	23	22	17	2	9	33	40	50	22	19	24	18	100.0

Table 4.2: The type of food taken from particular plant species and the months in which it was obtained.
Foods obtained are categorized as: sap and wood pith, fruit and seeds, nectar and invertebrates.

Food Type	Tree food obtained from	Month
Sap/ Pith	*Coprosma spp*	All year
	Five Finger/ Pauahou (*Pseudopanax arboreus*)	All year
	Karaka (*Corynocarpus laevigatus*	April, May, June, July
	Kawakawa (*Macropiper excelsum)*	March, April
	Mahoe/ Whiteywood (*Melicytus ramiflorus*)	All year
Fruit/ Seeds	Dogwood (*Cornus florida)*	March, April
	Five Finger/Pauahou (*Pseudopanax arboreus*)	August September
	Mahoe/ Whiteywood (*Melicytus ramiflorus*)	March, April
	Mapou (*Myrsine australis*)	April
	Totara (Podocarpus totara)	February, March,
	Rewarewa (Knightia excelsa)	May, June
	Fuchsia/ Kotukutuku (*Fuchsia excorticata*)	January,February
	Hinau (Elaeocarpus dentatus)	March
Nectar	Fuchsia/ Kotukutuku (*Fuchsia excorticata*)	November,
	Mahoe/ Whiteywood (*Melicytus ramiflorus*)	November
	Kowhai (*Sophora tetraptera*)	October, November
Invertebrates	Pine (Pinus radiata)	All year
	Totara (Podocarpus totara)	November
	Gorse (*Ulex europaeus*)	May

4.3.2 Foraging Patterns

All the adult Kaka spent between 32% and 52% of their time at the feeder. (Figure 4.1). The more time a bird spent at the feeder, the less time it spent foraging. RR-P had the highest level of sap foraging and the lowest level of the feeder use. RP-P spent more time foraging on invertebrates than the others did. RP-P used the feeder more than any other birds probably because he was provisioning the female on the nest. OB-P also had a high use of the feeder. RW-P is excluded from further analysis, as she was seen only seven times before leaving the valley (Chapter 3).

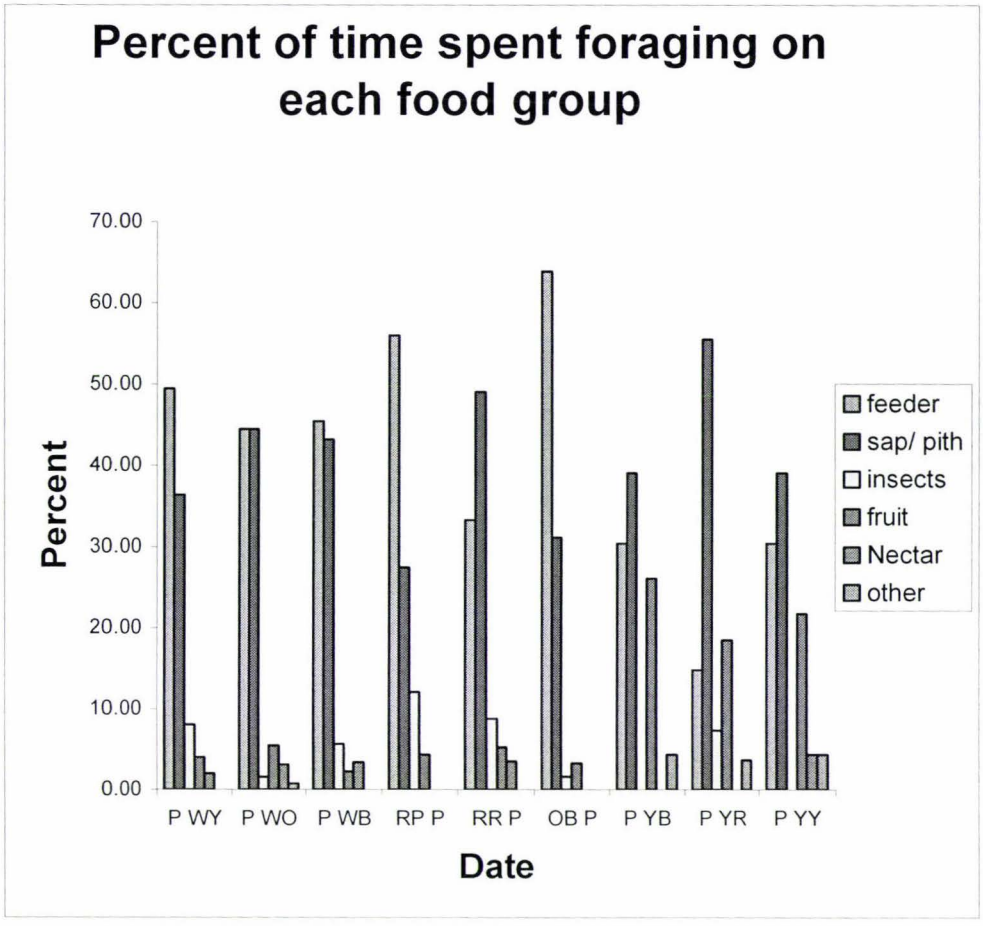
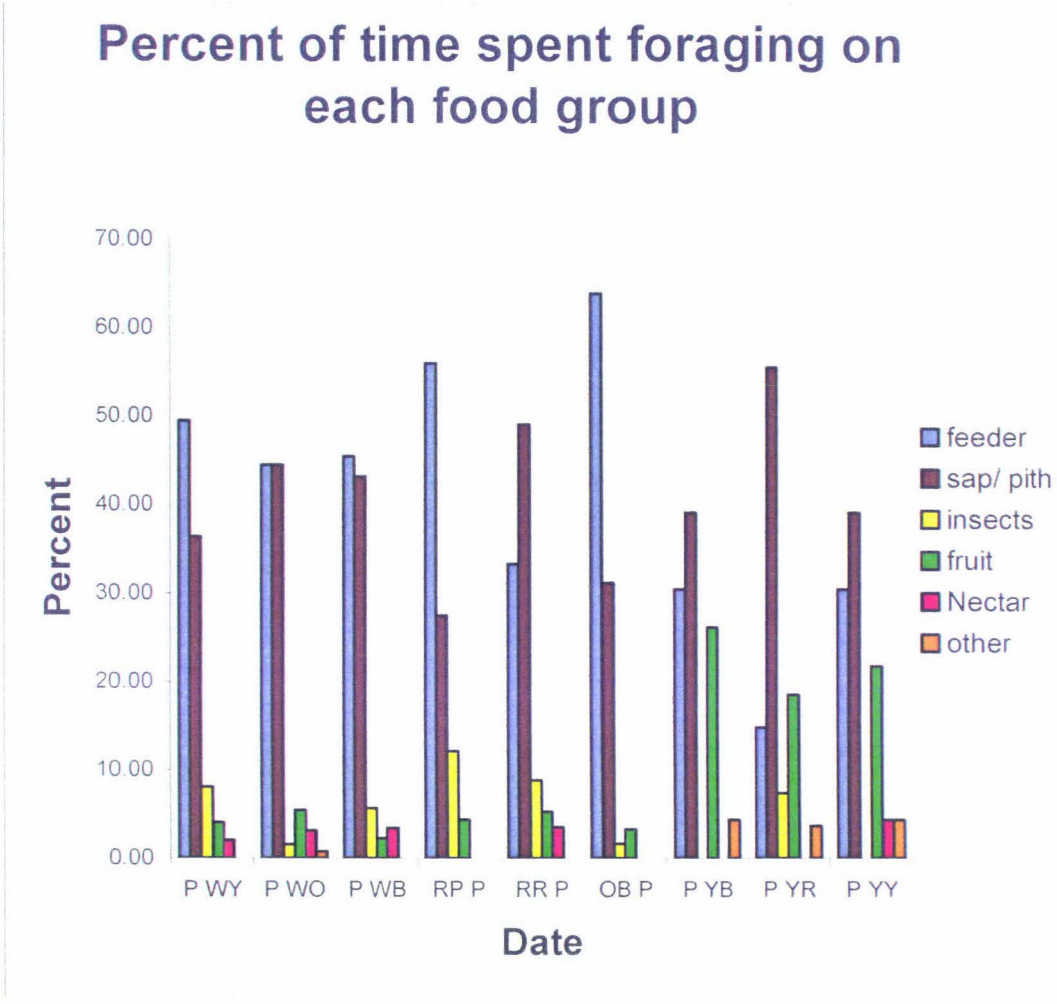


Figure 4.1: Percentage of different food types eaten by individual Kaka over the observation period

This was from the last week in August to 2002 to the last week in August 2003. "Feeder" is the use of either the Tui Terrace Supplementary Feeder or the Dam supplementary Feeder. "Other" refers to foraging on mosses and epiphytes (unknown species).

The chicks, P-YB, P-YR and P-YY, all started using the feeders at different times and in varying degrees. P-YR did not use the feeder as often as the other two chicks and took more sap. The chicks took more fruit than the adult birds did. Fruit, particularly Dogwood was very plentiful and easily obtained at the time the chicks fledged. The parents fed the chicks in March and April and after that the chicks started to forage more for themselves.



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The greatest use of the feeder was during the summer months, December through April (Table 4.3). There was a very large peak in feeder use in February. This was probably due to the high usage of the feeder by the nesting pair. The highest use of fruit was in February, March and August 2003. Foraging on sap and wood pith tended to be highest in autumn (February to June), with a second smaller peak in spring (September to November). Flowers were mostly taken in October.

Table 4.3: Number of observations of each food type each month.
Foraging activities are: At feeder including both Tui Terrace and the Dam feeder. Collecting sap and wood pith, collecting invertebrates, foraging on fruit and nectar, and foraging on other including moss and epiphytes.

	August	September	October	November	December	January	February	March	April	May	June	July	August
At feeder	0	6	2	27	27	31	98	37	16	12	6	9	5
Sap/ Pith	2	22	17	26	6	14	35	22	27	13	25	18	12
Invertebrates	1	1	4	6	0	1	4	5	2	1	4	6	1
Fruit	1	0	0	0	0	0	9	3	14	3	0	1	9
Nectar	0	1	10	0	0	0	0	0	0	0	0	0	1
Other	0	1	0	0	0	0	0	0	0	1	0	1	0

All the Kaka except RP-P spent between 43 and 67% of the their foraging time in the canopy (Figure 4.2). RP-P spent more time than the other Kaka in the under-storey foraging for insects. He was also the only one to spend more than 20% of his time in the sub-canopy. He was the only Kaka to seek out human contact and interact with people, and he spent the most time (excluding RW-P) at the feeder.

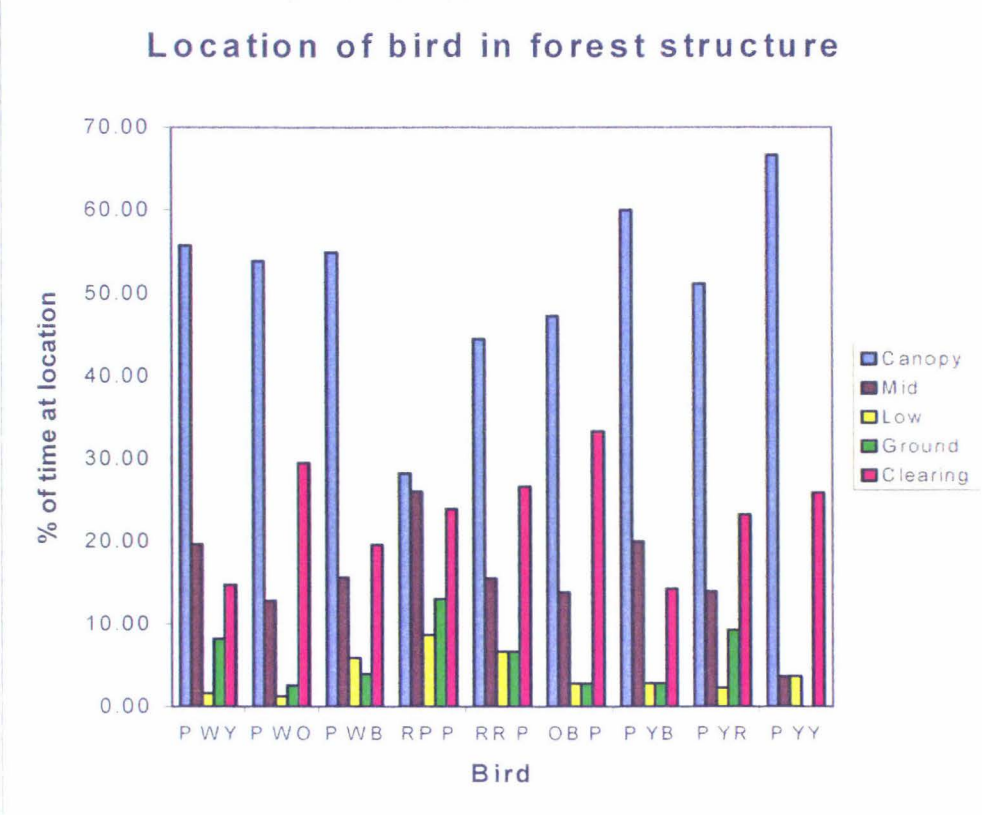


Figure 4.2: Foraging location of individual Kaka within the forest structure.
The canopy is the top of the trees and upper branches. Sub-canopy is the mid-branch and trunk level and top of non-emergent trees. The under-storey is the shrubby vegetation and ground cover.

Table 4.4: The foraging locations of the all Kaka per month.
The canopy is the top of the trees and upper branches. Sub-canopy is the mid-branch and truck level and top of non-emergent trees. The under-storey is the shrubby vegetation and ground cover.

	August	September	October	November	December	January	February	March	April	May	June	July	August
Canopy	2	20	16	8	9	10	28	19	39	11	23	19	9
Sub-canopy	1	2	3	2	5	2	11	9	11	7	8	2	4
Under-storey	0	0	1	0	3	1	0	1	4	3	2	1	0
Ground Level	0	0	2	0	0	3	2	2	3	3	6	3	0
Edge of Clearing	3	1	6	6	1	12	15	3	17	7	11	6	11

The Kaka were most frequently in the canopy. The amount of time the Kaka were seen in the canopy coincides with the times the Kaka spent most time foraging for sap (Table 4.3, 4.4) i.e. in September, February, and June. The peak in time spent in the sub-canopy occurred during February, March and April. The increased time spent in the canopy may have been linked to the increase in foraging on sap in autumn, but more precisely coincides with foraging on fruit, which also peaked in February, March and April. The increase in observations of the Kaka in the under-storey in April, May, and June is probably related to the time fledglings spent near the ground. The fledgling chicks spent time in the undergrowth before becoming strong enough to fly, and during that time foraged on moss and ferns. The Kaka foraged for invertebrates in the leaf litter and decomposing logs, and this accounts for the constant but low level of observations of Kaka on the ground. There is a slight rise in June again due to the chicks' presence. The peak in observations of Kaka at the edge of clearing may be the effect of the nesting pair using the feeder more at that time, and then using it with the chicks once they had fledged.

4.3.3 Activity Budget

The Kaka spent most time at the feeder (Table 4.5 and 4.6). The next largest portion of time was spent foraging on sap and wood pith. The least amount of time was spent foraging on nectar. Within the forest structure, most of the time was spent foraging in the canopy for sap. Among the non-feeding activity the largest percent of time was spent climbing, followed by perching and calling. For the adult Kaka, 47 to 68% of all activity was feeding. For the chicks this was lower, 26 to 42%.

Table 4.5: Total activity budgets for each bird.

Actives are in three groups. Feeding: feeding at feeder, feeding on sap or wood pith, feeding of invertebrates, feeding on fruit, feeding on nectar, and feeding on other including epiphytes and mosses. The locations in the forest canopy are: In canopy, mid level branches, low in the under-storey, on the ground and near a clearing. The activities for non-feeding are: perching/ resting, preening, climbing (investigating/ moving through branches), calling and interacting with other birds, sleeping with head under wing, and other including - sitting on the observers head, and nesting.

	P-WY	P-WO	P-WB	RP-P	RR-P	OB-P	P-YB	P-YR	P-YY	Total	%
Feeding											
Feeder	49	57	40	51	19	39	11	4	7	277	45
Sap/ pith	36	57	38	25	28	19	17	15	9	244	40
Invertebrates	8	2	5	11	5	1	1	2	0	35	6
Fruit	4	7	2	4	3	2	6	5	6	39	6
Nectar	2	4	3	0	2	0	1	0	0	12	2
Other	0	1	0	0	0	0	0	1	1	3	1
Total	99	128	88	91	57	61	36	27	23	610	100
Level											
Canopy	34	42	28	13	20	17	21	22	18	215	51
Mid	12	10	8	12	7	5	7	6	1	68	16
Low	1	1	3	4	3	1	1	1	1	16	4
Ground	5	2	2	6	3	1	1	4	0	24	6
Clearing	9	23	10	11	12	12	5	10	7	99	23
Total	61	78	51	46	45	36	35	43	27	422	100
Activity											
perching	26	15	8	11	3	5	15	21	16	120	18
preening	7	16	6	6	3	7	2	4	0	51	8
climbing	33	34	18	22	14	13	17	27	18	196	30
calling	28	15	16	13	2	7	8	11	8	108	17
sleeping	20	17	7	5	4	0	4	11	5	73	11
other	43	3	2	45	0	0	3	2	3	101	16
Total	157	100	57	102	26	32	49	76	50	649	100

Table 4.6: Percentages of time each bird spent on each activity.
The activities are: All feeding activity, perching/ resting, preening, climbing (investigating/ moving through branches), calling and interacting with other birds, sleeping with head under wing, and other - including sitting on the observers head, and nesting.

	P-WY	P-WO	P-WB	RP-P	RR-P	OB-P	P-YB	P-YR	P-YY
Feeding	38	56	61	47	68	65	42	26	31
perching	10	7	6	6	4	5	18	20	22
preening	3	7	4	3	4	8	2	4	0
climbing	13	15	12	11	17	14	20	26	25
calling	11	7	11	7	2	8	9	11	11
sleeping	8	7	5	3	5	0	5	11	7
other	17	1	1	23	0	0	4	2	4

4.3.4 Social Interaction

In August and September 2002, the two females that had been released were seen together five times (Table 4.7). After P-WB was released, he was seen more frequently with P-WY than P-WO. This reversed in October, and P-WB and P-WO spent more time together. In November, RP-P and P-WY stared courting and spent more time together than with the other birds. The two females P-WO and RR-P, tended to spend more time with each other than the two males RP-P and P-WB spent together. However, P-WO and RR-P still spent time with RP-P and P-WB. P-WY and RP-P nested in December, and the chicks fledged in March (see chapter 5). In January and February, OB-P (the initially un-banded wild male) arrived and was most frequently seen with P-WO. However, he was also seen with P-WY, P-WB, and RR-P but not RP-P. P-WO was also seen frequently with P-WB in February. The fledging of the chicks dominated March. The fledglings and P-WY RP-P were a family unit and stayed together and this pattern continued into April and May. The chicks started gaining some independence in May and stated to venture off at different times with different siblings. In June OB-P was often seen with the family group, and he seemed very interested in the chicks. During this time, P -WO and RR-P were also seen together frequently.

Table 4.7: Matrix of number of observations of Kaka seen with other Kaka each month.

Month	Bird ID	P-WO	P-WB	RP-P	RR-P	OB-P	RW-P	P-YB	P-YR	P-YY	P-YP
2002 August	P-WY	3									
September	P-WY	2	3								
	P-WO		1								
October	P-WY	3	3								
	P-WO		5								
November	P-WY	6	8	9							
	P-WO		7	7							
	P-WB			4							
December	P-WY	1		11							
	P-WO		4	1							
	RP-P		1								
2003 January	P-WY			10							
	P-WO		4	4	2	7	1				
	P-WB			3	1	1	1				
	RP-P				3	1	1				
	RR-P					1					
February	P-WY			7		1					
	P-WO		9	3	4	13					
	P-WB			4	5	7					
	RP-P				2	3					
	RR-P					7					
March	P-WY			13				3	6	3	1
	P-WO				5	1					
	P-WB				2	1					
	RP-P					1					
	P-YB								1	1	1
April	P-WY	1		6		2		7	9	5	5
	P-WO			1		1		1	1	1	
	P-WB				1						
	RP-P					3		7	4	7	2
	RR-P					4			7	9	
	P-YB					2				10	4
	P-YR					3					1
	P-YY					1					
May	P-WY			2				2	2	3	
	RP-P							3	2	3	
	P-YB								6	8	
	P-YR									6	
June	P-WY		1			1		2	2	2	
	P-WO		1			1				1	
	P-WB					2		1	1	2	
	P-YB					1			2	3	
	P-YR					1				4	
	P-YY					2					
July	P-WY				1	1		1		1	
	P-WO		1		1	1		1	1	1	
	P-WB					1		1	1	2	
	RR-P					1		1			

	P-YB	2		1	2	
	P-YR	1			2	
	P-YY	1				
August	P-WY	2			1	1
	P-WO		1		1	
	RP-P		1		3	1
	P-YR		1			1

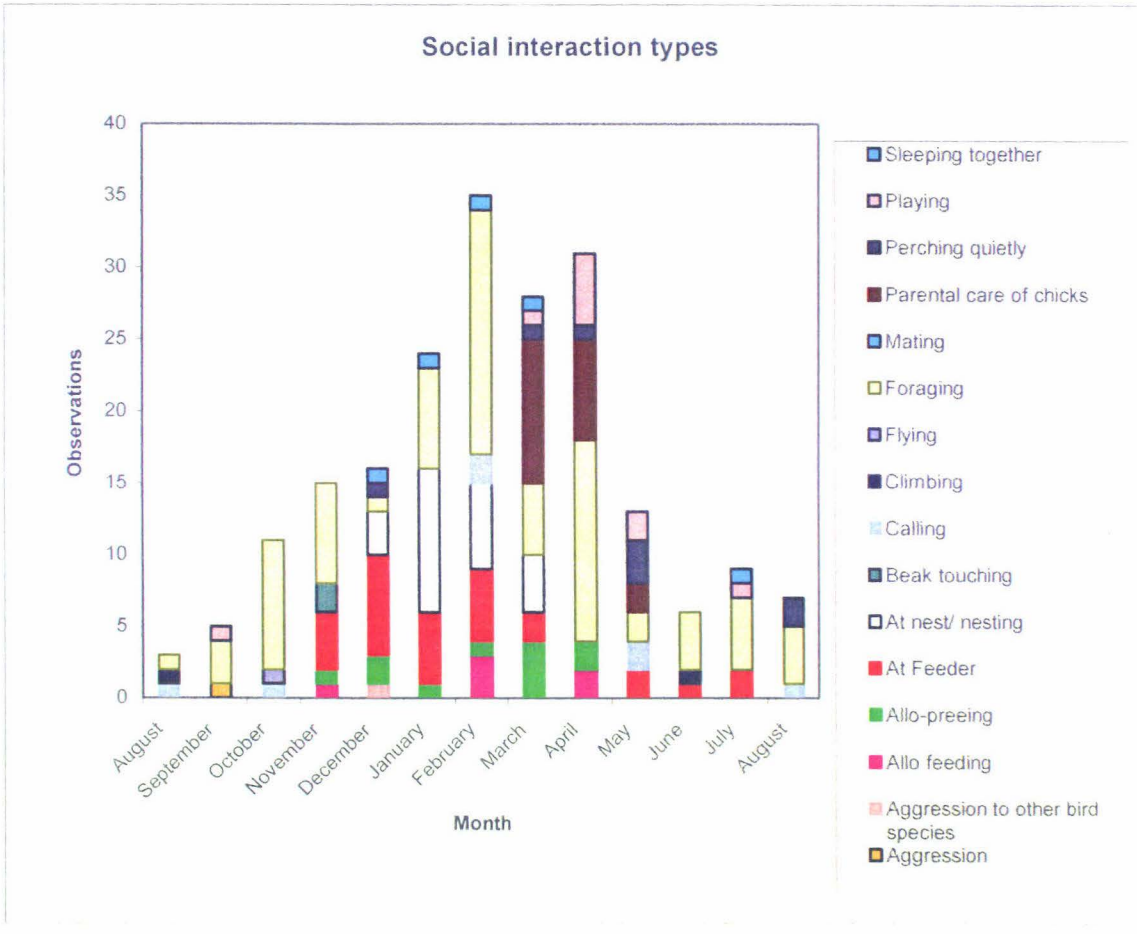


Figure 4.3: Activity Kaka participated in while interacting with other Kaka each month. Parental care of chicks includes touching, preening and feeding. At nest/ nesting encompasses the courtship nest investigating, courtship feeding, nesting itself, and provisioning of female by male while she was incubating. Aggression is the displacement or chasing of one bird by another.

The most common activity for the Kaka to be seen doing together was foraging (Figure 4.3). This was greatest in February and again in April, possibly due to the courtship between RP-P and P-WY and then the foraging with the fledglings in February and April respectively. The chicks spent a lot of time engaging in play. The Kaka were most often seen together at the feeder in November, December, January, February and March, coinciding with the months of highest overall feeder use. The occurrence of the one incidence of aggression toward another bird, a Tui (*Prosthemadera noveaseelandiae*) is also in December. The Tui was chased off the feeder. The Kaka's elevated use of the feeder may have driven the aggression. Calling together was most common in the two months after release and again during nesting. Due to nesting and pair bonding and the parents preening the chicks, allo-preening is increased in March. Aggression between the Kaka is recorded once in September, when P-WB was newly released and was chased off by P-WY after he flew in her direction.

4.3.4 Socialisation.

The birds did not call much while in the aviary. They did chatter and coo to each other while in the aviary but it was not until after they were released that they started to call. Once released, the Auckland females were the first to start calling to each other in a call that was reminiscent of a wolf-whistle. The call would start low, go up an octave, stop, and then the same note would be repeated in reverse. The call was similar to, but was not a wolf-whistle, so I do not believe it was learned from their keepers. They also did the atypical parrot squawk. The Hamilton birds started using the same communication call after release, so they presumably learned it from the Auckland birds. It seems to be a location declaration call. The Kaka use the squawk in alarm, and before taking to the wing, or when flying high overhead. This call seems to be a be a "take flight" call. They use the two in conjunction, often giving the wolf-whistle-like call, then squawking without taking flight themselves. This may be a simple syntax sentence asking another to fly now to the caller's location. I noted this particularly with the nesting female. She would do this to call her mate. When

arriving at the location of another bird, the wolf-whistle was always given. The birds would no doubt be able to identify each other by voice.

4.4 Discussion

Captive-reared Kaka adapt easily to a new habitat and successfully integrate into a new environment. How Kaka adapt to the environment may be different for each population and cultural differences may eventuate. The socialisation of the flock is important to keep it cohesive. The integration of the flock into the new habitat may be enhanced in this way.

4.4.1 Natural forage.

The Kaka at Karori seemed to adapt to natural food quickly and easily. They spent the majority of their time foraging and used a wide rage of tree species. The Kaka that left Karori successfully foraged on natural foods while they were gone, proving that they did not need the supplementary food for survival. The trees that I introduced them to in the aviary (Five finger and Coprosma) continued to be the most frequently used tree species after release. This was most likely due to the abundance of these species in the vegetation at Karori, rather than because of familiarity generated in the aviary. The use of natural foods provided in the aviary did not increase over time. This suggested that the Kaka were not learning to use these foods but rather used them instinctively.

The suitability of the sanctuary for Kaka seems to have been proven by this study. Some Kaka were not seen at the feeder for extended periods of time (RR-P in the months following release), while still remaining in the sanctuary. This suggests the suitability of the vegetation at Karori to support them. RP-P used the pine trees on the eastern scarp to forage for insects indicating that the Kaka used different vegetation types effectively and learned the spatial differences in vegetation around the valley. The Kaka showed temporal shifts in diet corresponding to the temporal differences in the vegetation types, indicating that they effectively adapted to seasonal availability of food. This suggests that the Kaka were able to integrate into the wild environment successfully.

O'Donnell and Dilks (1989) found that sap feeding occurred in late winter and spring. I found that the Kaka at Karori forged on sap mostly in September, October, February, and March (spring and autumn). Whilst all the birds had a similar peak in sap foraging in spring, the peak in Autumn was not as consistent and covered a wider range of time periods. The winter peak observed by O'Donnell and Dilks (1989) may not have been evident at Karori because of the supplementary feeding. However, this did not account for why the spring peak did match the one observed by O'Donnell and Dilks (1989). The resources available in winter may have been different than those encountered by the Kaka in O'Donnell's (1989) study. His study was conduced in Westland, and the abundance of food may have been less in the South Island than in the more temperate Wellington climate. The Kaka may not have experienced a food shortage at Karori. O'Donnell did point out that Kaka may not forage on sap when other food sources were abundant. Berry (1998) found that Kaka spent 40% of their time foraging on sap and the Kaka at Karori also spent 40% of their time foraging on sap. This similarity in percentage of sap foraging time may be indicative of Kaka foraging ecology.

The Kaka seemed to flock to the feeder at dusk to consume food before nightfall. Berry (1998) also found that Kaka at Mount Bruce did this. She suggests that Kaka use the supplementary food to top up nutritional deficiencies at the end of the day. It may have been to fulfil energy requirements overnight. Another study by Beggs et al. (1987), found that Kaka fed on honeydew at dusk and early in the morning, times of high-energy requirement. Kea also foraged at dusk to top up before nightfall. Jarrett and Wilson (1999) found that Kea foraged at dawn and dusk at Haplin Creek Rubbish tip, Arthur's Pass. Observing this behaviour in the Kaka at Karori is another indication of Kaka adapting to the wild habitat. This pattern of foraging ecology may be useful for monitoring wild Kaka populations, and may be important for management.

Berry (1998) suggested that the captive-reared Kaka released at Mount Bruce might have benefited from having wild-caught Kaka released along with them. The wild-caught Kaka were experienced foragers and may pass on some of this

information to the captive-reared Kaka. The Kaka at Karori did not have the benefit of this experience but showed no problems with foraging on natural foods. My observations suggest that the Kaka at Kaori weren't disadvantaged in any way by a lack of experienced birds. Survival rates at Karori were slightly higher than that of the Kaka at Mount Bruce. In this case, captive-reared Kaka do not require an established population to ensure the release success. This is an important finding as it indicates that future releases can be done to establish new populations successfully. More possible sites are available for establishment of the new populations, and the species would benefit from an increase in numbers that this would allow.

Another issue raised in the literature is the difference in foraging ability by the different sexes due to different beak sizes. Bond et al. (1991) talked about the dimorphism in bill size between male and female Kaka, and suggested the possibility of intersexual differences in niche utilisation. I saw little evidence of this for the Kaka at Karori. I did see RP-P spend hours foraging for insects on pine logs but occasionally saw females also do this. Females therefore were able to do this, even if they did this less than some males. The food gathered by the males was the same as that of the females and there was no evidence of niche specialisation between the sexes.

The larger beak of the male may be a sexually selected trait, or a device for male combat to gain a female. Overt aggression over females was not observed at Karori. Moorhouse et al. (1999) suggested that the extended provisioning of females and juveniles by the male might have led to the dimorphic bill condition. Moorhouse et al. (1999) suggested that as the Kea also has sexual dimorphism in beak size, this is an ancestral character. Moorhouse et al. (1999) went on to say that most parrots are dimorphic in body size and plumage colours, whereas the Kaka is not suggesting a loss of body size and plumage dimorphism due to reduced inter-male competition. They suggest that it was female selection on male provisioning ability that drove the evolution of sexually dimorphic beaks. That is, females may have chosen their mates based on provisioning ability, indicated by beak size, making beak size a sexual selection trait.

The observation that Kaka are not dimorphic in plumage (and this is the case in many New Zealand birds) raises an interesting question. In Kaka, both sexes are cryptically coloured yet they evolved in a predator-free environment. Predation is usually the evolutionary pressure driving the evolution of camouflage. Kaka would not have had this pressure so why are they camouflaged? Was the ancestral parrot colouring similar and by coincidence camouflaged the bird in the New Zealand bush? This may be the case if the Kaka ancestor evolved in a place with predators, like Australia. Another factor instigated by predation that needs to be considered is the changing sex ratio. Females are becoming rare in areas without predator control (Green and Fraser. 1998, Wilson et al. 1998), and the disproportionate male-to-female ratio may alter the Kaka's natural monogamous behavioural condition. Females are more susceptible to predation then males during nesting causing a population skew toward males. This can increase inter male competition (Green and Fraser, 1998) and can lead to possible disruption of pair bonds effecting the outcome of any nesting attempts. Competition can become much more intense than would normally be observed and can even lead to the death (Wilson et al. 1998). Wilson et al 1998 postulates that the nest could become more obvious to predators with the extra activity in the vicinity if a second male is present, making it more prone to predation. Nests could also be abandoned if a competing male drives off the breeding male and a second nesting attempt made by the second male.

Time will tell what the long-term effect on the population will be, but it may be very detrimental to Kaka reproductive success exacerbated by the slow replacement rate of Kaka and the long life span. One other major influence on breeding success is the provisioning of supplementary feeding (Wilson et al. 1998). This is important were competition for food from introduced mammals and insects is high. Wilson et al, (1998) observed that breeding success can be improved by supplementary feeding, Kaka that use supplementary feeding were seen to produce more fledglings.

4.4.2 Supplementary Feeding

Supplementary feeding is widely practised as a management tool to ensure the survival of endangered species. It is a way of providing support for the animals, particularly when the species' natural food source is restricted, contaminated or non-existent. Many studies have been done on the benefits of supplementary resource provisioning, and Berry (1998) lists several. The rationale behind supplementary feeding is to increase breeding productivity and the survival rates of a given population. In the case of Karori, the provisioning of supplementary food was to ensure that the captive-reared birds released into the sanctuary would have a reliable supply of food and to ease the transition into the wild. However, there was a risk that the presence of supplementary food would decrease the Kaka foraging on natural foods and jeopardise their integration into the wild.

The benefits of providing supplementary feeding outweighed the risks. Among the benefits were providing food for times when natural resources availability was low, to encourage site fidelity, and make birds visible for the public. At Mount Bruce, the Kaka flocking at feeding time has become an attraction for visitors. Berry (1998) found that the Kaka using the feed stations spent less time foraging on natural foods and more time resting than Kaka not using the feed stations. She found that the Kaka that used the feeders the most were the captive-reared ones. The higher use of feeders also affected other behaviour. Captive-reared birds tended to spend more time interacting together than the wild-caught ones. She put this down to the fact that the Kaka congregating at the feed station provided more opportunity for interaction. The Kaka at Karori all used the feed station frequently except RR-P, and she tended to have a lower level of social interaction than the other Kaka did. She also spent less time calling than the other Kaka. This supports Berry's (1998) findings.

The Kaka used the feeder regularly, and although it could not provide them with complete nutrition, it was still important. At Karori, 45% of total foraging time was spent at the feeder. All the adult Kaka except one used the feeder more than foraging on natural foods. RP-P and RR-P were both siblings, but RP-P used the feeder the most while RR-P used the feeder the least. This suggests that the

difference was individual rather then due to origin. However, if RP-P was not breeding he may have used the feeder less, and this would reveal if the Hamilton Kaka were different from the Auckland Kaka in foraging patterns, as they are in dispersal patterns.

Berry (1998) found that the captive-reared birds foraged more on supplementary foods than the wild ones did. She puts this down to the captive-reared Kaka having familiarity with the feeder. This may have been the case at Mount Bruce, but the Kaka at Karori were all equally familiar with the feeder, yet RR-P used it much less than the other Kaka. The replacement of the dog bowl and roasting tray with the Windsong feeder did not seem to affect the use of the feeder either. The Kaka were completely unfamiliar with this feeder but learned to use it quickly.

To our knowledge, OB-P had never used supplementary feeding before arriving but picked it up very quickly and used the feeder more than P-WB and P-WO. His foraging patterns and use of the feeder were similar to those of the captive-reared Kaka. This may show that there is no difference in supplementary feeder use resulting from familiarity with the feeder, or at least that with another Kaka already familiar with supplementary feeding to teach a wild Kaka there is no difference. He may not have needed to use supplementary food, but he was adaptable enough to learn to do this. This indicates that wild Kaka can effectively adapt to environmental change. A lot is expected of captive-reared Kaka adapting to the wild, but little thought is given to wild populations and what impact environmental change is having on them. The fact that they are as adaptable as captive-reared Kaka may be useful if management in the future involves hands-on management and supplementary feeding of wild populations.

4.4.3 Learning and knowledge exchange between birds.

The calls that the Auckland Kaka performed after release were learned and used by the Hamilton Kaka once they intermingled. This call combination may be unique to Kaka at Karori. The calls at Karori are anecdotally reported to be different from other Kaka populations. Further study will be needed to verify this. Three Kaka from Otorohanga Zoo arrived and were introduced to the aviary just

before I finished my fieldwork, and were released in September 2003. They did not have the same call used by the Karori Kaka when they arrived, if they pick it up and start using the Karori call may show that new birds entering an existing population lean the local dialect in order to integrate in to the existing population. When OB-P first arrived, he did not make this call either but soon picked it up and now uses it as well. It is not surprising that location calls did not develop until after release as they are not needed while in captivity. Nevertheless, how the Kaka developed the distinct call is interesting. Having been captive their entire lives the Kaka have never had the need for a location call, and they would never have been taught one. Did they choose a random call to denote location, or was it some other mechanism?

Studies on Budgerigars (Hile et al. 2000) showed that pairs developed the same call with in 2.1 weeks, and that these distinctive calls were important in pair bonding. Distinctive calls may also serve in flock formation. The development of a pair call contributes to pair bonding and pair maintenance. Siblings may use calls in the same way, and the Auckland Kaka may have developed a distinctive location call to maintain the flock. This call was then passed on to the Auckland birds, as it was already an established location call for the flock. The Yellow-naped Amazon parrot (*Amazona auropalliata*) has distinctive population dialects (Wright and Wilkinson 2001). However, in this species dialect was not related to genetic inheritance. Calls were not connected to a related group, in other words were not genetically inherited, but were connected to a distinct location. At Karori, it may not have been the sibling group that was important, but rather the fact that one sibling group formed the flock prior to the other being released. They established a distinct location call at Karori first and this transferred to the second group released.

The development of a distinctive dialect was not the only knowledge exchange that took place. The resident birds taught OB-P how to use the Windsong feeder, and he now uses it regularly. P-WY and RP-P taught their chicks how to use the feeder, and the chicks now use feeders regularly as well. OB-P watched the other Kaka using the feeder and called vigorously to them. He then went to the feeder and experimented with using it but was unsuccessful. He got frustrated

when he could not get the feeder lid open. At this stage RR-P fed him, then showed him again how use the feeder while he was nearby watching. Knowledge exchange is an indication of culture, and the exchange of information by the Kaka may denote a culture unique to the Kaka at Karori. As social birds it is not surprising that they have a strong group bond, but it was interesting to see just how complex it was. If a culture has evolved at Karori then other populations will probably have their own culture. This is an important consideration for management of Kaka populations, and the ramifications of changing population structure must be considered.

4.4.4 Pair Bonding

One of the questions of interest was whether the pair bond between RP-P and P-WY would continue over winter. Following the chick's fledgling RP-P and P-WY did still interacted with each other for several weeks. When the chicks gained independence at the end of April, RP-P stopped interacting with P-WY but was still seen interacting with the chicks on occasion. The pair bond obviously resumed in the spring of 2003, as P-WY and RP-P nested again (see epilogue). This suggests that the pair bond did not last over the winter months, but that Kaka may pair for life and the pair re-establishes itself at the start of each breeding season. This would mean that we might have to consider breeding pairs to be mated for life for management purposes. Birds that are seemingly solitary in winter may still have a mate that they are bonded to, and populations must be managed to account for this. There may be a large impact on the social structure of the population if birds are removed. This is particularly relevant for wild populations.

4.4.5 Family Structure

There were continued sightings of one or more of the chicks with one or both parents throughout the winter, and they continued to socialise as a family unit into August 2003. The parents stopped feeding the chicks in May, and started integrating back into the flock In July and August 2003. In August the whole flock was often seen together. There are several reports of the chicks and several adult Kaka foraging over in Dalton Park, and occasionally up south of the lake on the western scarp. Kaka chicks usually become independent after five months

(Heather and Robertson 1996). The Kaka chicks fledged at Karori seemed to have gained independents by May. This is only a period of two months that they received support from their parents. Their parents were still seen with them and may been showing them how to forage but were not feeding them. The shorter time may be due to RP-P and P-WY being captive-reared. They may not have had the experience enough to support the chicks for longer. The chicks foraged for themselves eating easily obtainable foods such as moss and fruit. They did not have the beak strength to open tree bark at that stage. This may be something adults do for chicks in the wild. The chicks relied on the dogwood fruit at this time and they consumed a lot of it. This suggests that captive-reared Kaka may need support after nesting to raise their chicks. Management of nesting captive-reared Kaka will involve monitoring the post-fledge period to determine development of independent foraging in the chicks. The development of the Kaka chicks pre and post-fledge will be the subject of chapter 5.

CHAPTER 5:

Nesting and Chick Development

5.1 Introduction

The breeding season is September to March, and Kaka may not breed every year. The eggs are laid and are hatched over a period of days, so the chicks vary in size for several weeks. Incubation is 23-25 days, and the chicks fledge after 60-70 days, becoming fully independent after 5 months (Barrie and Robertson 1996; Moorhouse et al 2003). Wilson et al. (1998) studied a population at Duckpond stream in the Nelson Lakes area, and found that over 10 years, only two nesting attempts were successful, and of these only two resulted in surviving fledglings. There was a high loss of nesting females, nestlings, and fledglings to stoats. Dilks et al.'s. (2003) study in Fiordland found that the presence of a stoat trap in close proximity to the nest could increase nest success. Moorhouse et al. (2003) also found that the presence of predators reduced nest success from 80% to 35%. Because of the significant impact stoats have on Kaka reproduction predator free environments such as at Karori may play a vital part in the management of the species. Such places may become the source of individuals for future translocations. Abundant food supply with little competition is the other factor influencing reproductive success.

Wilson et al. (1998) also showed the importance of Beech seed for Kaka nesting success and noted that no nesting occurred when Beech did not seed. While Beech may not be so important in the North Island, Moorhouse (1991) also emphasized the importance of food availability for Kaka nesting on Kapiti. He suggested that as Kaka nesting is restricted to years of abundant food supply the effect of competition from introduced mammals would further reduce nesting success. Because Kaka do not reproduce every year, their productivity may not be as high as other parrots of the same size (Moorhouse, 1991). This further exacerbates the decline. On Kapiti Island, where food supply is limited because of the small size of the Island, starvation was the biggest cause of nest failure, and only 40% of the nests were successful. The supplementary food supply provided at Karori may reduce nest failure resulting from lack of food availability. Powlesland and Lloyd (1994) showed that supplementary feeding of Kakapo (*Strigops habroptilus*) on Little Barrier Island induced a low level of breeding

activity whereas no breeding occurred otherwise. Therefore supplementary feeding may enhance breeding success in some instances.

It is unusual for Kaka to breed at one year of age but not unheard of. Alley et al. (2002) and Moorhouse and Green (1995) discussed female Kaka who bred at one year of age, or at least still retained the juvenile pale eye ring. Alley et al. (2002) did state that one year of age was the earliest known breeding age for any wild Kaka. Berry (1998) observed 15 incidents of mounting behaviour over a six month period, and the Kaka she studied were only nine months old when released. It was not expected that the Kaka released at Karori would reproduce in the 2002-2003 breeding season. The Kaka at Karori were young, about a year old when released, and they still retained the pale eye ring - although it had nearly disappeared. However a pair of 1-year old Kaka did nest at Karori.

The key questions were "could these captive-reared Kaka nest successfully?" and "could they fledge chicks and raise them to independence?" Would they adapt to nesting in the wild and instinctively know what to do and would they know how to raise and provision the chicks while on the nest and after fledging? RP-P and P-WY would not have had the benefit of being shown correct provisioning behaviour, as this would not be necessary in captivity. The female could access her own food in the aviary with a very limited time off the nest. Their knowledge of chick care may also be lacking, as this may not have been fully expressed by captive parent birds. Breeding of captive-reared Kaka has not been observed closely in the wild, so this study provided an excellent opportunity to monitor nesting behaviour, provisioning of the female by the male, the development of the chicks and their progress to independence. The question of whether the male and female remain paired over the winter after the chicks gain independence will also be addressed.

Pair bonding cements the partnerships for the breeding season necessary in bird species like the parrots that require high parental input to raise young. Kaka chicks are dependent on their parents for five months. The female incubates the eggs for up to 25 days and is not able to forage for herself to meet her energy needs during this time. Nests are abandoned if the female does not receive

adequate food (Moorhouse and Green 2003). Paternal involvement is therefore necessary to ensure nesting success. The maintenance of the pair bond over the winter is not discussed in the literature, and this is an unknown in the case of captive-reared individuals nesting in the wild. This study may reveal the fate of pair bonding over winter, and if and how the pair bond is reestablished again in the next breeding season.

The use of artificially nest boxes is necessary at Karori because in the regenerating bush at Karori, there are few trees old or large enough to contain a cavity of nesting size. The use of nest boxes has not always been successful with other species of parrots. The Yellow-shouldered Parrot (*Amazona barbadensis*) had a poor success rate when using artificial nest boxes, and a design problem or an abundance of available nest holes were implicated as the reasons for this (Sanz et al. 2003). As captive-reared birds, the Kaka at Karori may have been predisposed to use artificial nest boxes and in fact may not have known how find or use natural nest sites. The sanctuary conservation team envisioned no problems with Kaka using artificial nest boxes.

This chapter will cover the period on nesting from initial pair bonding to the family structure after chicks become independent. I will be observing the courting behaviour, the nesting process, chick development and fledging, and the interactions between the parents and chicks post fledging. I will monitor nesting to determine the length of incubating and non-incubating periods over the duration of nesting, and the frequency of male provisioning of the female. The weights of the chicks will be monitored and their development tracked. Once fledged, the fledglings will be observed to determine level of parental involvement and their dispersal. I hope to determine if these processes are similar for those documented for the species, and if not, the significance of being captive-reared. The ultimate goal of this chapter will be to determine whether captive-reared Kaka can successfully fledge chicks and to determine the processes involved. I will be monitoring the incidence of pair bonding and maintenance. Understanding the ecology of the nesting process will be valuable in managing other captive-reared Kaka, and hence achieving successful nesting in them.

5.2 Methods

The nest boxes were built at the sanctuary and were 105cm (height) x 30cm (length) x 30 cm (width) (plate 5.1). The entrance hole was near the top of the box and there was an internal and external perch. The nest boxes were installed in the aviary while the Kaka were still in it so they could gain familiarization. 12 nest boxes were installed in pairs at locations regularly used by the Kaka (plate.5.1). The locations of the nest boxes are: two on the western scarp above the Tui Terrace feeder, two on the western scarp near the top of W Line, two on the eastern scarp north of the Beech Track not far from W Line, two in the Totara grove under the top dam, two above the Valley View Track by V Line, and two on S Line near the Fuchsia Track. The exact location of the nest boxes is not divulged for security reasons but this information can be obtained by contacting Raewyn Empson at the Karori Wildlife Sanctuary. The nest was video taped using the sanctuary video camera (unknown brand), set on a tripod. The nest was taped on random times and days when staff could load the tape, taping usually lasted 3 hours when the tape ran out. The tapes were viewed and the activity recorded. The behaviour of the pair was observed and recorded with the interaction type and length. The dispersal and behaviour was also monitored as before. A Windsong feeder was placed by the nest box for the nesting pair to use.

The chicks were weighed regularly. Before they were old enough to put bands on they were identified with markings on their toes. When old enough, they were banded in the same way as the adults, with a pink metal band (left leg) and two coloured bands (right leg) to distinguish individually. On 21/03/2002, transmitters were put on the chicks in the same way as for the adults.

Plate 5.1: Photo of the front of Nest box 2.

5.3 Results

5.3.1 Pair Bonding

RP-P started courting P-WY in November 2002, almost immediately after he returned to the valley. He was seen following P-WY around and trying to touch her. The courting involved RP-P feeding P-WY and them mutually preening each other. They spent a lot of time foraging together and calling and chattering to each other. While he fed her she hunkered down, flapped her wings, fluffed up her feathers, and gave a distinctive begging call. This was distinctive behaviour different from the upright postured begging that the chicks performed. These are typical patterns of begging (Moorhouse et al. 1995). RP-P started trying to mount P-WY in December and became more and more persistent with her. I saw him trying to get close to her when he first returned to the valley. P-WB tried to chase him away, but he persevered. He was seen courtship feeding her on November 20. P-WY was seen investigating the artificial nest boxes on November 27, and settled on nest box number 1. This box was on the eastern scarp facing east up the hill. It was just above a disused logging track off W Line, north of the Beech Track.

5.3.2 Laying

P-WY laid her fist egg on 28/12/2002 (Table 5.1). Her second egg was laid around the 01/01/2003, the third egg laid on the 02/01/2003, the fourth on 05/01/2003, and the fifth and final egg laid on 08/01/2003. I saw her before her fourth egg was laid and she appeared very heavy with eggs, and moved very slowly.

5.3.3 Incubation

Three eggs hatched on 23/01/2003, one more on 26/01/2003, and the final egg hatched on 28/01/2003 (Table 5., Plate 5.1). The eldest egg was incubated for 26 days the second egg hatched after 22 days, and the third and fourth egg hatched after 21 days (Plate 5.2). The last egg was incubated for only 20 days.

Table 5.1: P WY dates of laying her five eggs, their date of hatching, and total days of incubation.
It is uncertain whether P-YY's egg or P-YR's egg was laid first, as these chicks are close in age.

Egg	Lay date	Hatch date	Incubation time in Days	Fledge Date	Toe markings	Leg bands	Transmitter frequency
1	28/12/02	23/01/03	26	28/03/02	W Left	P-YP	N/A
2	01/01/03	23/01/03	22	26/03/02	W Right	P-YY	77
3	02/01/03	23/01/03	21	24/03/02	R Right	P-YR	73
4	05/01/03	26/01/03	21	28/03/02	R Left	P-YB	71 and 89 x 14/07/03
5	08/01/03	28/01/03	20	N/A	N/A	N/A	N/A

5.3.4 Nestling stage

On 06/02/2003, the smallest chick died. It was 16g and only lived nine days. It had an empty crop when found. The likely cause of death was underdevelopment and starvation. When RP-P fed P-WY, he usually arrived on the nest lid or in a tree nearby and called to her. She would emerge, either to the perch outside the nest or in the tree nearby with him. He would regurgitate food to her once or several times in succession. The regurgitation lasted about 5-10 seconds each time. He would feed her once or twice in the morning and again once or twice in the afternoon.

The nesting pattern of the female was monitored by examination of the video data (Figure 5.1). In the first month she spent most of her time on the nest. Most of the observations showed her spending more than 80% of her time on the nest. In the last days of December, and the first half of the month of January, the average incubation time was 160 minutes and the time spent away from the nest foraging or resting averaged 30 minutes. The time spent on the nest gradually decreased as the month of January progressed, and she spent more time away

from the nest. In mid January the trend lines crossed and she was spending equal amounts of time on the nest as away from it - about 140 minutes. After that she increasingly spent more time away from the nest than on it. In March, the amount of time the female spent on the nest was nearly zero. At this stage the chicks were quite large, and it would have been difficult for the female to fit into the nest. She did spend a lot of time away feeding and making many brief visits to feed the chicks. She appeared to visit up to five times in a few minutes as the chicks got near to fledging.

Regression line for the time in minutes spent in the nest is:

In = 85158 - 2.26 C1

Predictor	Coef	SE Coef	T	P
Constant	85158	15049	5.66	0.000
C1	-2.2586	0.3996	-5.65	0.000

S = 68.65 R-Sq = 48.4% R-Sq(adj) = 46.9%

The regression line for time in minutes spent away from the nest is.

Out = - 144505 + 3.84 C1

Predictor	Coef	SE Coef	T	P
Constant	-144505	18466	-7.83	0.000
C1	3.8425	0.4903	7.84	0.000

S = 84.23 R-Sq = 64.4% R-Sq(adj) = 63.3%

The P value of the regression lines shows that there is a statistically significant relationship between date and time spent in the nest at the 5% significance level, for both time spent in and out of the nest. The negative slope of the line for time spent in the nest shows the negative relationship with time, and conversely the

time spent away from the nest is positive. The residual values for both lines vary around zero randomly, showing that this is not a logarithmic relationship.

There were three outlying points that are of note. On the 23/01/2003, P-WY was on the nest for 301.21 minutes. As the view on the video of the nest was from the back on this day it was very hard to see her coming and going. She may have left and then returned without being seen. On the last day of video recording, 28/03/2003, P-WY was away from the nest for 153.22 and 134.33 minutes. P-YR had just fledged, and her parents spent a lot of time with her, not visiting the nest often. The other chicks were in this way encouraged to fledge if they wanted to secure food from their parents. P-YR fledged on 24/03/2003, P-YY fledged on 27/03/2003, P-YP fledged on the 28/03/2003, and P-YB fledged on the 29/03/2003.

5.3.4 Nestling weight

The Kaka chicks (besides the one that died) all put on weight, increasing by about 300-350g in the first 18 days (Figure 5.2, Plate 5.3 and 5.4). After 17/02/2003, weight gain started to level out. On 26/02/2003, the weight of the largest three started to drop. It was at this stage that Raewyn Empson made the decision to start crop feeding the chicks warm wombaroo mix daily. The feeding was based on protocols held at the sanctuary. After that the weight of the chicks started to increase again, but they only put on between 22 and 57 grams from the 26/02/2003 to the 27/03/2003. The smallest put on 81g after the 26/02/2002 and was the same weight as the elder chicks when it fledged. P-YY and P-YR had a decrease in weight gain from the 21/01/2003 on. The weights then fluctuated, with the chicks sometimes losing weight between weighing. The variance may be in due to the chicks being fed before being weighed. One bird was weighed before and after feeding and a full crop added 22g to the chick weight.

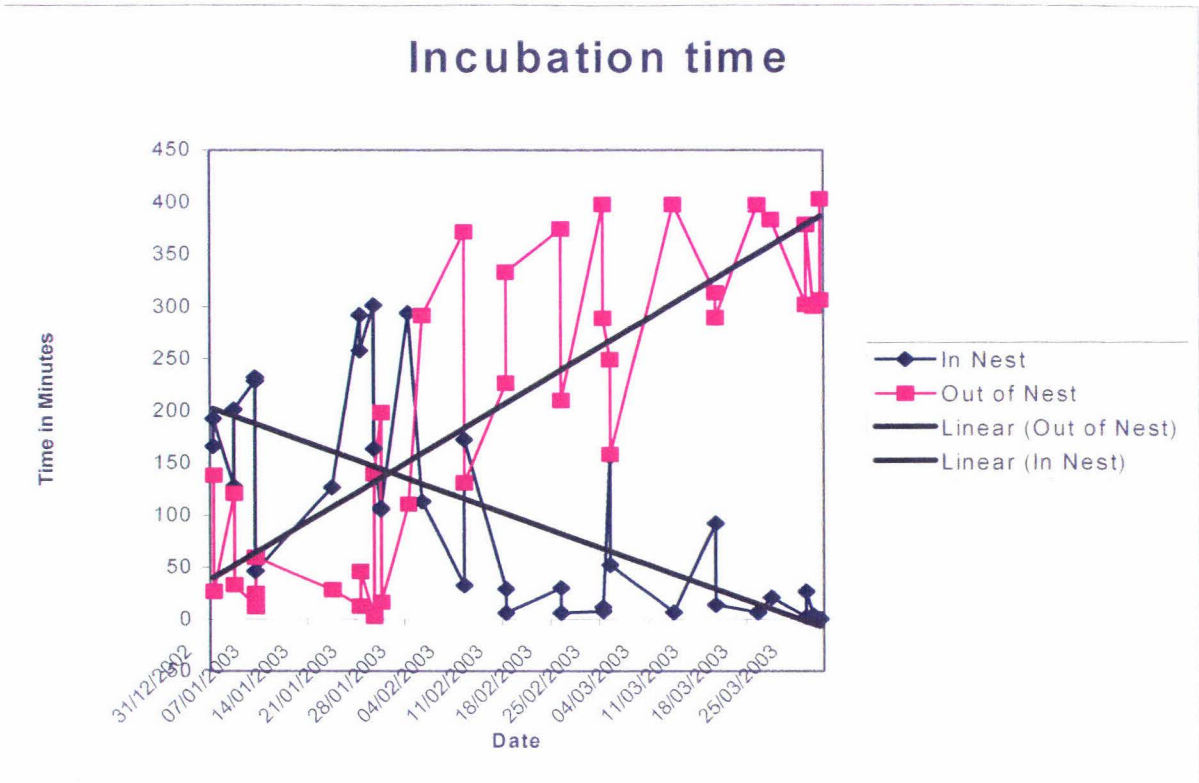
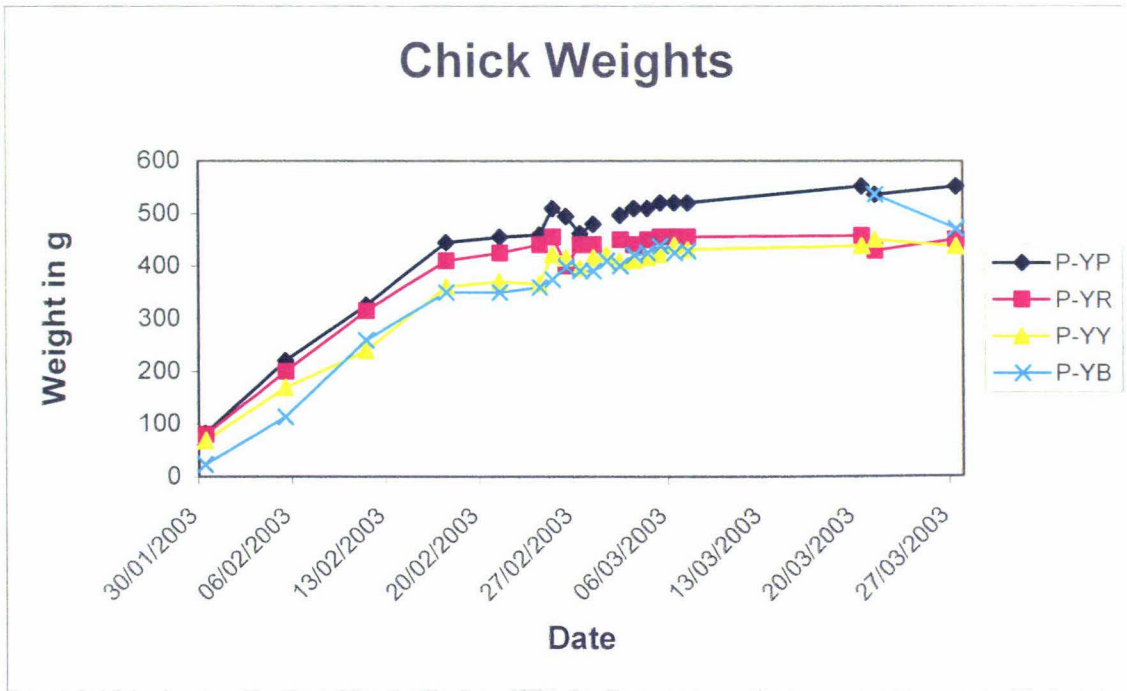


Figure 5.1: Incubation time showing time in minutes spent in and out of the nest.

Figure 5.2: Weights (g) of Kaka chicks at Karori from hatch date to fledge date



4.3.5 P YP

P-YP was fledged on 28/03/2003. He remained near the nest site in the following two days. On 01/04/2003, he fell out of a tree and was unable to move his legs, although he could still move his wings. He was found before he got hypothermic, as it was a wet day. He had probably slipped on wet branches. He was taken to the Kilbirnie Vet, and stabilised. Two days later he was transferred to the Zoo hospital. He was hand fed as he was unable to use his feet to feed himself. He has since slowly regained the used of his feet and can now stand on his feet and feed himself. He can perch on branches but has a weak grip, and has limited strength in his legs and feet. He may not get full use of his legs back. He is also now very human imprinted and will most likely be unable to integrate back into the flock. He will remain permanently at the Zoo. The last that I heard is that he is to be placed into a larger outdoor cage alongside a one eyed Kea.

Plate 5.1: Photo of Kaka eggs at Karori Wildlife Sanctuary (16/01/2003).
Photo by John Shorland.

Plate 5.2: Photo a Kaka chick hatching at Karori Wildlife Sanctuary (23/1/2003).
Photo By John Shorland.

Plate 5.3: Kaka chick at Karori Wildlife Sanctuary (7/02/2003).
Photo By John Shorland.

Plate 5.4: Kaka chick in nest box at Karori Wildlife Sanctuary (11/01/2003).
Photo By John Shorland.

5.4 Discussion

5.4.1 Pair Bonding

As with most parrots, Kaka pair bond. The reason for pair bonding is to ensure that both parents will participate in the rearing of the young. This is important when the young are altricial, and both parents are needed to provide enough food for the young (Brewer el al. 1975). The process of pair bonding can facilitate the connection between the male and female. In birds pair bonding involves calling to each other, allo-preening, courtship feeding, nest site selection, and in some cases a ritual courtship dance. Masello et al. (2002) concluded that paternal care plays a crucial role in the evolution and maintenance of genetic monogamy in burrowing parrots (*Cyanoliseus patagonus*). The pair bond guarantees paternity for the male and so may benefit him in this way. If involvement of the male is required to raise young pair bonding may evolve. If not the male will not pair bond and polygyney may evolve. Kaka chicks are dependent on both parents for five months (Barrie and Robertson 1996), and the female is dependent on the male during incubation, so the ecology of the species suggests that Kaka should form a monogamous pair bond. This is in fact the case. The pair bond may be so strong as to change the participating individuals physically. The zebra finch (*Taeniopygia guttata*) studied by Remage-Healey et al. (2003) is a case in point. The finches showed neuroendocrine responses on separation of a pair, alleviated only by the return of the removed pair bonded mate.

The duration of the pair bond in Kaka is unknown. Three things could happen to the pair bond in this case; it may be maintained over the winter period. It may last only as long as the chicks are dependent on the parents but be resumed again in the next breeding season. Or it may be dissolved completely after the end of the breeding season with both birds finding other partners the following season. In the case of the Kaka at Karori the bond lasted for as long as the chicks were dependent on the parents and then seemed to dissolve. The pairing was however re-established in the next breeding season (see epilogue). If this pattern proves typical of Kaka this has implications for management of Kaka populations. If a Kaka is solitary over winter months it cannot be assumed that it is not still actively pair bonded. This will impact translocations from established

populations, both wild and captive. Removing one of a pair from a population may upset the social dynamics of the population, and hence the remaining member of the pair will have to bond to another bird in the new season.

The female is the sex that is investing most into the reproduction effort, so has the most to lose if the pair fails. This may explain why it is that in many bird species she is the decision-maker in regard to accepting a courting male and pair bonding with him. In other bird species this has caused the evolution of fitness displays in male birds such as flamboyant plumage and nest or bower construction. The courtship feeding observed in Kaka may be one such fitness display. The observations of the courting activity at Karori suggest the male courted the female and she either rebutted his advances or accepted them. She also makes the choice of nest site. The females were the ones that inspected the nest sites at Karori. With the Kaka at Karori the length of time RP-P and P-WY spent establishing the bond may reflect its importance to the success of the nesting attempt. Before nesting began, RP-P and P-WY spent nearly one month in courtship feeding, allo-preening and foraging together.

Continued courtship feeding and vocal communication contribute to the maintenance of the pair bond. Allo-preening may also strengthen the bond by imprinting the bond on the individuals. This ensures that both parties will remain in the pair bond and fulfil the obligation of provisioning the young to come. The vocal communication may involve a pair distinctive call. Roberston (1996) discussed the importance of vocal recognition of a mate as important in the silvereye (*Zosterops lateralis*). The calls of the silvereye were distinctive enough to allow individual recognition. Budgerigar pairs develop a unique call over a period of 2.1 weeks (Hile et al. 2000). Furthermore it is the female that instigates the call and the male imitates her. This adds further weight to the theory of female choice driven pair bonding. Kaka are flock birds and they spent a lot of time cooing and chattering to one another. This promotes the development of voice recognition and further building of the bond, as in the Zebra finches.

5.4.2 Incubation Time

Barrie et al. (1996) gives an incubation time of 23-25 days. The chicks at Karori were all hatched outside this window, one having a longer duration of incubation and the other four were shorter. The developmental stage of the eldest and youngest chicks was very different at hatch. Either these chicks were not normal cases, or the estimated incubation times may need to be revised. The age of the parent Kaka may have been the cause of the aberrant incubation times. Asynchronous hatching is a feature of Kaka reproduction, but because P-WY was so young, she may not have produced eggs as quickly as an older bird might. This may have extended the laying period and caused the incubation times to change, however the chicks still hatch as synchronously as possible, within a couple of days of each other thus improving their chance of survival. In the blue-footed booby (*Sula nebouxii*) the eldest chick out competes its smaller siblings for food (Rodriguez-Girones et al 1996). This may also happen in Kaka chicks with the older chick receiving more of the food, the younger siblings must be able to compete so may need to be similar in size. This may dive the synchronous hatching and may explain why the fifth chick was malnourished, it was too small to compete. The chick died with an empty crop possibly after its remaining yoke ran out after hatching, and its parents failed to provision it adequately.

In bird species where only one nestling per nest is fledged asynchronous hatching insures against the failure of the first egg. Parrots and Kaka both fledge more than one offspring per nest, so they do not hatch asynchronously for that reason. However in this case the female may not have been able to produce her clutch as rapidly as an older bird instead producing them over a period of days thus spacing out hatching dates. The repeated mating observed may also be needed to produce a full clutch. Stoleson and Beissinger (1997) studied asynchronous hatching in Green-rumped Parrotlet (*Forpus passerinus*). They manipulated nests so that some nests hatched asynchronously (the normal pattern) and some synchronously (chicks were all the same age). They found generally no difference between the two nest types, but greater fledgling rate occurred on experimentally increased (eight chicks) clutch sizes as long as nests were synchronous. They also found that mortality in chicks that were very

asynchronous occurred within 12 days of hatching, and that the chick died with an empty crop due to parents provisioning the chicks inequitably.

5.4.3 Chick survival

The female was reliant on the male to provision her and he regurgitated food to her while she was nesting. Observations suggest that he fed her infrequently and she was often seen emerging to the lid of the nest and calling for his return. He may not have provisioned her adequately and she may have been away from the nest more than she would have been otherwise finding her own food. As very little close monitoring of Kaka nesting patterns has been attempted there is no "average rate of provisioning" to compare this pair with. What the normal rate of male provisioning of a nesting female is a topic for future research. Nest abandonment may result (Moorhouse et al. 2003) if the female is insufficiently provisioned. At Karori the supplementary feeder placed near the nest may have prevented this. If this is the case, supplying supplementary food to captive-reared breeding pairs may have to be included in management plans.

Renton el al. (1999) studied the nesting cycle of the Lilac-crowned Parrot. They found that throughout the nesting cycle, females and nestlings were fed once a day on average. Attendance at the nest cavity was short 10.6-11.2 minutes. Nest attendance during the feeding visits was short. The infrequent feeding visits by Lilac-crowed Parrots corresponds with that found for other main-land Amazon parrots in north-eastern Mexico, but contrasts with the multiple feedings and longer nest attendance observed for island Amazon species. Kakas also have the multiple feedings and longer nest attendance exhibited by the Amazon island parrot species. This suggests that the Kaka more closely follow the reproductive ecology of an island living parrot rather than that of a continental one. The advantage of this is that Island Bird species tend to need fewer founders than continental species (Cade et al. 1994). This would make them more suitable to translocation management strategies.

Dilks et al. (2003) found a survival rate for their monitored nests of 80%. The success rate was high even though predation occurred and mice were present competing for Beech seeds (*Nothofagus spp.*). Stoats were the main predators

on nests, and nests were successful if a stoat trap was located nearby. This would suggest that large-scale stoat control over a large area may not be necessary, and localized concentrated protection of nesting locations may insure successful nesting and a sustainable population. Wilson et al (1989) showed the importance of predator control for the success of breeding attempts, however they noted that mice and rat populations increased when stoat numbers were controlled. Moorhouse (1990) also showed that when stoats are removed rats become the main predator on some occasions and seriously affect nest success rates, particular for nests with openings close the ground. A reduction in numbers of the top predator leads to an increase in other introduced predators and competitors and this could be detrimental to Kaka reproductive success. This is an example of when an introduced animal has become a keystone species. The upshot of this is that future management plans either insure supplementary feeding for the Kaka is implemented to eliminate competition issues or manage rats, mice and any other introduced species known to compete with Kaka. This is obviously a very big ask. Wilson et al. (1998) found that over 11 years, there were 20 breeding attempts at Nelson Lakes and only four fledglings survived to independence. At Karori 80% of the chicks fledged and 60% became independent. However, with such a small sample size it is impossible to compare the success rate of captive-reared Kaka nesting at Karori and those nesting in other locations.

The lack of food and provisioning of the female on the nest would by far play the major role in nest failure if predation were removed as a factor. Moorhouse et al. (2003) studied nesting on predator free Kapiti Island and found a success rate of only 14%. They found the main cause of nest failure was nest abandonment due to lack of food. Kapiti is a small island, with a small carrying capacity, and a lack of food is more likely to be a problem than on the mainland. Forest fragmentation on the mainland may make habitat carrying capacity a management issue in the future. Kaka may be a good indicator species as they are large birds, so may suffer the effects of lack of food before small species would. Establishing habitats large enough to support a viable population of Kaka may become a benchmark for protected area sizes in the future. At Karori, the supplementary food provisioning would make lack of food less of a problem. Type of food

available may also be relevant. Wilson et al. (1998) suggests that at Nelson Lakes Kaka reproduction is strongly linked to a distinct food source such as Beech seed. The linking of one food type to nesting success may not be so important in the North Island as the temperature is milder and the Kaka are less likely to have food supply shortage.

5.4.4 Use of nest boxes

As noted in the epilogue, P-WY and RP-P nested again the 2003-2004 season. However, they did not use the same nest box for either of their following nesting attempts. As Moorhouse (1990) points out, Kapiti Island Kaka sometimes use the same nest site again that same season or in the following season if the nesting fails. This may be a necessity due to a lack of suitable nest holes and Kaka may prefer not to do this. The fact that the birds chose to use a different nest site each time may reflect the abundance of artificial nest sites at Karori. The quantity and quality of the nest locations must therefore be carefully considered when designing a release plan.

5.4.5 The Chicks

Moorhouse et al. (2003) also found chicks become independent and started foraging for themselves three months after fledging, the observations of these chicks development matches the literature. In late June and early July the chicks started to forage for themselves on soft easily obtainable foods like Dogwood fruit and mosses. This seems the normal timeframe for wild Kaka and does not suggest that the captive-reared Kaka are any different from wild-born Kaka in this respect. The weight gain pattern of the chicks compares with the chick weight gains the chicks at Mount Bruce exhibited. The chicks at Mount Bruce had a peak in weight gain about halfway through their development and then the weights declined. The same decline was evident in the Karori chicks at the same age, however the crop feeding that the sanctuary staff conducted may have prevented this decline. The decline may have been a natural development pattern. Determining the natural development pattern may assist breeding management in the future. Diversions from the expected norm may be a cause for intervention, but there may be natural fluctuations in weight we can allow for.

5.5.6 Summary

Captive-reared Kaka can successfully fledge chicks in the wild at approximately one year of age. They may need monitoring to ensure that the male is provisioning the nest adequately. The amount of days to hatching may be inconsistent with current literature, but weight gain in the chicks will equalise size differences in the chicks. The rate of population growth seen in the Karori population suggests that captive-reared Kaka will replace early losses quickly and will go into a positive growth phase within one to two years. Predator control may be an ongoing need, and a supplementary feeding plan may be necessary to ensure success. Nest boxes are a successful tool in the nesting of captive-reared Kaka. Management of Kaka populations can incorporate nesting as part of a short-term plan for a population. A future field of study could be that of determining the amount of Kaka chicks that suffer accidents like P-YP did and are lost to the population in that way.

CHAPTER 6:

Conclusion

6.1 Introduction

Griffith et al (1989) considered a reintroduction to be successful if it resulted in the formation of a self-sustaining population. The release at Karori was successful in the fact that the Kaka remained at the sanctuary, had a high survival rate, and seemed to be able to forage effectively on natural foods. Griffith et al. (1989) also pointed out that the success of a release could depend on the method of release, the source of the population (wild or captive-reared), and the health and number of the source population. This in turn depends on the species concerned. Both the Kaka releases at Karori and at Mount Bruce involved captive-reared Kaka and both releases have been successful, suggesting that using captive-reared Kaka to found new populations is a viable management tool. Scott et al. (1987) looked at the benefit of translocations to an existing population, in to which new birds are being released. They list the benefits as being: increasing the number of animals in a small population, increasing genetic diversity in a small population, reducing inbreeding depression in small populations, and establishing new populations. As the existing population at Karori grows these issues may become more important. The genetic drift may become an important consideration, especially if P-WY and RP-P continue to disproportionately contribute offspring to the population (see epilogue).

6.2 Research Findings

6.2.1 Chapter 2: Pre-release feeding and behaviour.

Determining the foraging ecology of animals is beneficial to the management of protected areas. Habitat restoration geared to the nutrition of the animals released to the habitat ensures reintroduction success and will ensure ecologically sound management. The Kaka showed marked preferences in food choices while in the aviary. There was no significant correlation between the two groups of Kaka and no significant temporal patterns. The Kaka showed

instinctive ability to forage on natural foods and did so eagerly. Although they were fed on a supplementary diet, they demonstrated that they were capable of meeting all their nutritional needs without supplementary feeding. Most of the Kaka put on weight over the duration of their stay in the aviary. Monitoring the weight of the Kaka would show whether any health or management issues had arisen, the Kakas' weight gain suggested that there were none. The consumption pattern did assist in the formulation of a post-release supplementary diet, and monitoring of supplementary feeding enabled efficient post-release supplementary feeding. The provisioning of natural foods assisted post-release integration into the new habitat. Neophobic responses were reduced and allowed effective adaptation to the wild environment. The dispersal around the valley and the Kaka survival rate will show how well the Kaka adapted to release.

6.2.2 Chapter 3: Survival and Dispersal

At Karori, site fidelity was an important issue because of the close proximity to the city. Although site fidelity was low in the first six months (three of the six released birds dispersing more than 2km away from the sanctuary), in the subsequent six months all but one of the released Kaka remained primarily within the sanctuary. The Kaka continued to venture out of the sanctuary, but returned and used the valley as a sort of home base, remaining within 1km of the sanctuary and staying in forested areas when out of the sanctuary. They are therefore not exposed to the urban environment, and the proximity of the city has not affected survival rates. Dispersal in the valley continues to be primarily centred around the release site at the upper dam and all the Kaka generally stay in this area. The location of the dam feeder in this area may be driving this dispersal pattern. The dispersal out of the valley may be driven by the location of forage outside the valley. However, the vegetation they forage on while outside of the valley is generally the same as what they obtain in the sanctuary, so this is probably not the primary factor influencing dispersal.

Overall, the population proved to be stable, with numbers increasing within 12 months of release. The longevity of the Kaka, high survival rates, site fidelity, and early breeding were the reason for this. One adult bird left the valley but

another wild adult male arrived maintaining the population at its original numbers. The fledged chicks increased the population numbers. Seeing a stable population in the first year after release is expected in long-lived birds. However, lack of site fidelity could have impacted this population severely. The fact that it did not is an important finding for future releases of captive-reared Kaka. Captive-reared Kaka seem to have a higher level of site-fidelity (Berry et al 1998) than wild-caught Kaka, so using captive-reared Kaka may be more suitable for translocation orientated management strategies. They will be more likely to stay in the release area, and this is an important consideration for managed populations.

The dispersal behaviour of the three Hamilton Kaka was more like the wild-caught Kaka at Mount Bruce (Berry 1998), and the Auckland Kaka behavior was more like the captive-reared Kaka behaviour exhibited at Mount Bruce. The Hamilton Kaka all dispersed out of the valley, although two of them eventually returned. The Auckland Kaka tended to remain close to the release site. The two Hamilton Kaka that returned to the sanctuary after a period of absence have remained.

6.2.3 Chapter 4: Post-release behaviour

Adaptation of released animals into the new environment is important for the success of the release. The way the Kaka interacted with the environment will determine if the Kaka can effectively integrate into the wild. The socialisation of the Kaka will determine if a cohesive flock can be established. The establishment of a cohesive flock will increase the success of the release. Foraging patterns will show if the habitat is suitable for the introduction of Kaka and will show what environmental factors are important in future releases. This will improve future restoration programmes.

The Kaka effectively utilised the resources in the environment both temporally and spatially. Foraging comprised most of the activity budget and using the feeder comprised most of this. The more Kaka used the feeder, the less they foraged on natural foods. Mahoe and Five finger comprised the largest portion of

the Kaka diet, and foraging on sap and wood pith was a major component of the Kaka activity budget. A distinctive location call emerged among the Kaka at Karori, possibly instigated by the Auckland Kaka. The knowledge of this call, and the use of the feeder were transferred to the wild male Kaka that arrived and the newly fledged chicks. This may show the development of a unique culture among the Kaka at Karori.

6.2.4 Chapter 5: Nesting and chick development

The nesting and successful fledging was an unexpected bonus, providing a population increase. RP-P and P-WY were only one year old when they nested. P-WY laid five eggs, all of which hatched. The smallest died, as it was underdeveloped when it hatched due to being incubated for only 20 days. Four chicks fledged but the eldest chick fell out of a tree damaging its back. Although it is still alive it will remain in captivity at the Wellington Zoo for the remainder of its life. The other three chicks successfully gained independence from their parents. Weight gain in the chicks while in the nest increased rapidly but then leveled off after approximately the first week. This weight gain pattern followed the trend of the weight gained by chicks fledged at Mount Bruce. The incubation times for the Kaka at Karori did not match the incubation times in the literature (Heather and Robertson, 1996), this may have been due to the youth of the parent birds.

6.3 Future management

The nesting ecology and the neophobia response were more closely correlated with that of island parrots then continental ones (Renton Salinas-Melgoza. 1999). Management of Kaka and other bird species in New Zealand must therefore be geared to island ecology. This suggests that Kaka will respond to environment management on small scales similar to island habitats, and may suit strategies such as Mainland Island reserves. Kaka make good candidates for reintroduction to these areas and will integrate easily into restoration programmes. Reintroductions should be managed as part of the long-term restoration of

ecological habitats. Reintroductions have generally been done with no underlying theory (Armstong and McLean 1995), and aimed solely at population growth of an endangered species. Ecological restoration is assisted if the species is reintroduced to its prior home range. The negative impacts of Kaka reintroductions on the environment are limited because we are not introducing a species into an area that was not part of the former range.

The release at Karori supported and extended the research by Berry (1998) at Mount Bruce. The important difference with the release at Karori was that the release location was close to an urban centre. Because of this site fidelity became an issue. The Kaka remained in the area of the release site and showed high site-fidelity, hence a high survival rate. The Kaka successfully integrated into the habitat and breeding produced a growth in the population, showing that site fidelity did not cause a major problem to population viability. Some of the factors that limit survival have been discussed in this study and include: neophobic responses to the new habitat post-release, socialisation and foraging deficiencies, supplementary feeding dependence, cultural development and knowledge sharing. Management of these increases the likelihood of the formation of a sustainable population. The benefit of current Kaka reintroduction practices for establishing new populations is assured if the current level of success is maintained. The issues affecting success can be understood and addressed by current knowledge. However, some new questions have now been raised and these will require consideration.

Wilson et al. (1998) predicts "stoat predation will cause Kaka to become extinct on mainland New Zealand unless stoats and/or Kaka are managed". This grim prediction sounds a warning bell that must be heeded. Kaka are disappearing from more and more forest remnants each year. Kaka disappeared from three out of four forests surveyed between 1979 and 1993 (Pierce et al. 1993). Stoat predation does not immediately impact the numbers of adult Kaka in a population, but nesting success is reduced considerably and the population is not replacing itself. This results in a slow decline in the population as adults die or leave the population. This process is slow as Kaka are long-lived and the effect of individuals being lost from the population may not be evident for several years.

This makes determining the health of Kaka populations very difficult. The early and successful breeding at Karori shows that Kaka can have a relatively rapid replacement rate, and combined with the longevity of Kaka, population growth can be achieved quickly.

While Stoat predation seems may have the largest impact of Kaka survival in the North Island (Moorhouse 1997), competition from possums (*Trichosurus vulpecula*) and wasps (*Vespula* spp.) (Beggs et al. 1991) may also be a problem. Possums have an overlapping diet including Misteltoes and Hinau (*Elaocarpis dentatus*), and Wasps compete for honeydew (Berry 1998). We have to act decisively now before the Kaka populations are reduced further, as it will be much harder to pull the Kaka back from extinction if it becomes critically endangered, and we may fail on this task. This species is a national treasure (taonga), and its evolutionary situation may be invaluable to the study of paleo-ecology in New Zealand, as well as contemporary ecology in all its guises.

In this case, besides all of the benefits of reintroductions listed above benefits to the sanctuary can also be identified. The release of Kaka at Karori makes use of the resources of the wildlife sanctuary at Karori, providing a public relations and scientific resource for the sanctuary, the Wellington region, and the scientific community. Karori provides a unique environment that is wild, but carefully controlled and manipulated. If supplementary feeding can improve the success and rate of nesting attempts, then Karori is the ideal place to study this. The lack of nearby feeder may have contributed to the failure of the second nesting attempt of P-WY and RP-P (see epilogue). Wilson et al. (1998) found that the presence of supplementary feeding alone did not induce Kaka breeding in years with no Beech masting, but for captive-reared Kaka it may have proved beneficial. The differences in use of supplementary feeding between captive-reared and wild-born Kaka may be an important consideration in managing populations.

One glaring question was the impact of the genetic history on the future of this population. Genetic drift is one of the major considerations when using translocations as a management strategy (Conant 1998). In the case of Kaka,

the risk of genetic drift causing health problems is low and can be reduced further by careful management. A study by Puller (1996) calculated that a managed population of up to 60 Kea is the minimum required to retain more than 90% heterozygosity over 200 years. Kaka may have a similar minimum viable population statistic and this needs to be considered for any management strategy. Starting a population like the one at Karori, with as diverse a genetic base as possible is important. National databases of the captive Kaka populations like the one that exists for Kea, would greatly aid the maintenance of a genetically diverse population. This would be one tool to help increase genetic diversity. All the captive birds over the entire country would be viewed as one single flock for management purposes.

How and what information is passed onto the chicks will provide important information in hand rearing and managing captive and wild populations of Kaka. These birds are obviously intelligent, and we will be able to manage and maintain them better if we learn just how intelligent they are. The way captive-reared birds interact differs from wild ones, and the education that captive-reared birds may miss out on may have been an important factor in the failure of nesting attempted in 2003-2004 nesting season (see epilogue). RP-P may not have provisioned her adequately. The development of a "culture" at Kaori is something that may need to be studied further in the future. If Kaka do show cultural evolution in other populations, then facilitating this in captive flocks may improve survival, prevent behavioral problems arising, and may improve the outcome of future releases. This may be an important ecological factor that changes future management practices.

RP-P's habit of sitting on peoples' heads could give an opportunity to study the effect of this sort of close human contact has on Kaka. This has not been formally studied, but the constant visitor stream watching even the most intimate activities of the birds (foraging, mating and nesting) may have detrimental effects on the birds. However, Kaka are gregarious birds and may be not be troubled by this. There are areas in the valley that were not frequented by people but the Kaka did not seek these areas out indicating that the presence of people did not

distress the birds. The unique environment can provide a fertile ground to study this topic.

The release of the Kaka into the valley has been a success overall. The Kaka showed that they could adapt well to a change in diet. They also showed that once released into the wild from captivity, using the soft release method, they showed a high level of site fidelity. Five of the six captive-reared birds survived and thrived, making the transition to the wild with little difficulty. This study also showed that captive-reared Kaka will successfully breed in the wild following release. This knowledge is valuable for any further release programmes using captive-reared Kaka. This release success and the success of captive-reared birds at Mount Bruce (Berry 1998) have shown that using captive-reared Kaka as founders of a wild population is a feasible and safe management strategy. This release in particular has shown that as few as six individuals may be released to provide the foundation of a stable population, a population that may be self-sustaining. There is no indication that they would not survive without supplementary food and nest boxes. The stable population is in part due to individual longevity. It has yet to be seen what effect genetic drift and the genetic bottleneck will have on the future of this population - only time will tell that. Ongoing monitoring of this population and others will provide long-term population fate information, and the long-term outcome of reintroductions. Only then will we see if reintroductions of Kaka are ensuring the survival of the species.

6.4 Epilogue

On 13/06/2003, 3 more Kaka arrived at the Sanctuary from Otorohanga. The birds were kept in the aviary and released in early September. There were one female and two males, with the Prime Minister Helen Clark assisting in the release. Unfortunately in early October, the female died. Sanctuary staff thought that she starved to death because she was unable to forage successfully. She was very timid while in the aviary and did not seem to be interested in exploring any novel object. She tended to remain hidden in foliage. She may not have had

the ability to adapt to a new environment and may have failed to adapt to the wild. These birds had the largest of the changes in diet to contend with. At Otorohanga and while in the aviary at Karori, they were fed Tofu, but this was not available to them once they were released. The two males remain in the valley and are interacting with the birds already established in the valley. They have successfully integrated with the flock and have adapted successfully to the habitat.

In 2003-2004 breeding season, RP-P and P-WY nested again and produced five more eggs. This time they nested further up eastern scarp of the valley, above the Valley View track. The chicks were doing well and gaining weight, but then developed what seemed to staff to be a nutritional deficiency, resulting in beak and feather deformities. Three chicks died, the fourth was taken to Massey University to try to correct this problem and will most likely become too imprinted on people to ever be released. The fifth chick remained in the nest but its parents abandoned it, the sanctuary staff taking over feeding and care of it. It successfully fledged and is now interacting with its parents. P-WY and RP-P nesting for a second time in 2003-2004 season and fledged 4 healthy chicks.

Wilson et al. (1997) found that some of the signs of nest failure during nesting are a decrease in nest attendance, increase in duration of absences, and increases in frequency of nest entries by females. Staff at the sanctuary anecdotally reported this behaviour. This change in behaviour may be a useful indicator of nest failure for other breeding operations. RR-P and P-WB also nested in the 2003-2004 season, using nest box one - the same nest site as P-WY and RP-P had used the year before (the nest box itself had been replaced). RR-P laid five eggs, all of which hatched and fledged.

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Appendix

Appendix 1: Individual Bird Data.

Band no.	35816		Colour bands	P-WY		Sex	female	Date banded	19/06/2002
Origin	Auckland Zoo			Hatch date	29/11/2001			Parents	970051 & KA0285
Date	Weight	Tx #	Bill length	Bill width	Tarsus length	wing length	tail length	Comments	
19/06/2002	350	-	43.3	12.2	36.6	265	150	transferred & released into aviary @ Sanctuary	
03/07/2002	355								
21/07/2002	353.5								
22/07/2002	361							Transmitter attached	
13/08/2002	375*							Transferred into Hn aviary;*weight incl. Tx	
23/08/2002	307*	85						Released into Sanctuary	
11/06/2003								tx recovered on ground	

Band no.	35823		Colour bands	P-WO		Sex	female	Date banded	19/06/2002
Origin	Auckland Zoo			Hatch date	03/12/2001			Parents	970051 & KA0285
Date	Weight	Tx #	Bill length	Bill width	Tarsus length	wing length	tail length	Comments	

19/06/2002	354		44.2	12.5	32.3	260	160	transferred & released into aviary @ Sanctuary
03/07/2002	358.5							
21/07/2002	358							
22/07/2002	363							Transmitter attached
29/07/2002								transmitter removed
13/08/2002	385							new tx attached
23/08/2002	380	95						Released into Sanctuary

Band no.	35839 (prev 35820		Colour bands	P-WB		Sex	male	Date banded	19-06-2002; rebanded 22/7/02?
Origin	Auckland Zoo			Hatch date	01/12/2001			Parents	970051 & KA0285
Date	Weight	Tx #	Bill length	Bill width	Tarsus length	wing length	tail length	Comments	
19/06/2002	426		48.5	12.5	36.6	273	170	transferred & released into aviary @ Sanctuary	
03/07/2002	375.5								
21/07/2002	433.5								
22/07/2002	438							Transmitter attached & rebanded	
29/07/2002								transmitter removed	
13/08/2002	445							new tx attached	
23/08/2002	453								
06/09/2002	454.5	83						Released into Sanctuary	

Band no.	35825	Colour bands	RR-P		Sex	female	Date banded	19/06/2002
Origin	Hamilton Zoo		Hatch date	29/10/2000			Parents	unk

Date	Weight	Tx #	Bill length	Bill width	Tarsus length	wing length	tail length	Comments
08/05/2002	359							Arrived Auckland from Hamilton & into quarantine
19/06/2002	372		44	12.2	35.4	277	160	transferred & released into aviary @ Sanctuary
03/07/2002	388.5							
21/07/2002	394.5							
22/07/2002	386							Transmitter attached
29/07/2002								transmitter removed
13/08/2002	390							transmitter attached & transferred to Auck aviary
23/08/2002	390							
06/09/2002	391							transmitter tightened
16/09/2002	391							transmitter checked
27/09/2002	402	91						release into Sanctuary

Band no.	35838 (prev. 35828)	Colour bands	RW-P	Sex	female	Date banded	19-06-2002; rebanded 22/7/02
Origin	Hamilton Zoo	Hatch date	29/10/2000	Parents	unk		

Date	Weight	Tx #	Bill length	Bill width	Tarsus length	wing length	tail length	Comments
08/05/2002	414							Arrived Auckland from Hamilton & into quarantine
19/06/2002	397		44	12.4	35.1	260	156	transferred & released into aviary @ Sanctuary
03/07/2002	406.5							
21/07/2002	428.5							
22/07/2002	385							Transmitter attached & band replaced

23/08/2002	411.5		transmitter reattached; transferred to auck aviary
06/09/2002	389		transmitter removed
16/09/2002	425		transmitter reattached
27/09/2002	422.5	93	release into Sanctuary

Band no.	35836	Colour bands	RP-P	Sex	male	Date banded	19/06/2002
Origin	Hamilton Zoo	Hatch date	29/10/2000	Parents	unk		

Date	Weight	Tx #	Bill length	Bill width	Tarsus length	wing length	tail length	Comments
08/05/2002	409							Arrived Auckland from Hamilton & into quarantine
19/06/2002	403		49	13	35	267	150	transferred & released into aviary @ Sanctuary
03/07/2002	398.5							
21/07/2002	427.5							
22/07/2002	419							Transmitter attached
29/07/2002								transmitter removed
13/08/2002	460							transmitter attached & transferred to Ak aviary
23/08/2002	428							released into Sanctuary
25/08/2003								recaptured Island Bay - put back in aviary
06/09/2002	437.5	81						released into Sanctuary
15/05/2003		81						Faulty tx replaced