Reintroducing Juvenile Kaka to Mount Bruce Reserve

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For Boots

so you can be
closer to free

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MORE Walnuts Please!

ABSTRACT

I investigated whether the release of juvenile Kaka (*Nestor meridionalis*) is an effective tool in the restoration of Kaka to mainland ecosystems. Five wild-caught juvenile Kaka and four hand-reared captive-bred juvenile Kaka were released at Mount Bruce Reserve in the North Island in June 1996. I assessed the suitability of each group for release by monitoring the survival rates, dispersal from the release site, and behaviour of the Kaka after release.

The Kaka were released using a soft-release method. The four captive-bred Kaka were reared in aviaries at the National Wildlife Centre (NWC) at Mount Bruce prior to release. The five wild-caught Kaka were captured on Kapiti Island in May 1996 then transferred to the NWC. The Kaka were held together in aviaries at the NWC for two weeks, then released on 4 June 1996. Post-release the Kaka were provided with supplementary food at feedstations set up at the release site. Each Kaka was fitted with a transmitter and was individually recognizable by colour leg-band combinations. I monitored the Kaka on a daily basis for six months after release.

Survival rates for both captive-bred and wild-caught Kaka were high after release, with 8/9 Kaka alive at 30 November 1996. Radio-contact with one of the wild-caught Kaka was lost in September.

There was high site-fidelity after release, with most of the Kaka moving a limited distance from the release site and generally staying within Mount Bruce Reserve. One wild-caught Kaka was located at Hokio Beach on the west-coast of the North Island in June 1996. This bird was captured and returned to the NWC. After being re-released at Mount Bruce Reserve in August 1996 this bird has remained within the Reserve.

The Kaka adapted well to the new environment of Mount Bruce Reserve, locating and feeding on a variety of natural foods, and interacting with each other after release. All four captive-bred Kaka and three wild-caught Kaka regularly fed at the supplementary feedstations after release.

These results suggest that it is possible to reintroduce Kaka to a mainland site. Translocated wild-caught juvenile Kaka will stay near the release site after release when released using a delayed-release method. Juvenile wild-caught Kaka and juvenile captive-bred Kaka can survive on the mainland in the presence of predators, when assisted by post-release supplementary feeding and low-level predator control.

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1.0 INTRODUCTION

1.0.1 Kaka populations in New Zealand

The Kaka (*Nestor meridionalis*) is a forest-dwelling parrot endemic to New Zealand (Bull *et al.* 1985). There are two subspecies, the North Island Kaka (*Nestor meridionalis septentrionalis*) which is the focus of this study, and the South Island Kaka (*Nestor meridionalis meridionalis*).

The total number of Kaka has been estimated at fewer than 10,000 birds, with the largest populations on offshore islands (Heather & Robertson 1996). There are relatively large and stable populations of North Island Kaka on Kapiti Island, Little Barrier Island, Great Barrier Island, Hen and Chicken Islands and Mayor Island (Heather & Robertson 1996). North Island Kaka are also present in localised flocks in the large forest tracts of mainland North Island, with the largest and most stable populations located at Pureora and Whirinaki. However these mainland populations of Kaka are thought to be declining (O'Donnell & Rasch 1991) due to habitat destruction, predation, and competition from browsing mammals and wasps Moorhouse 1990, Beggs & Wilson 1991, Wilson *et al.* 1998).

1.0.2 Threats to Kaka Populations

Productivity of Kaka is generally low and infrequent, with nesting occurring in years when food supply is abundant (O'Donnell & Rasch 1991). The breeding success of South Island Kaka in beech (*Nothofagus*) forests is related to the mast seeding of beech trees (Wilson *et al.* 1998). Breeding success of North Island Kaka on Kapiti Island, which lacks most of the introduced competitors present on the mainland, is also related to food abundance (Moorhouse 1990).

In addition to typically low productivity, Kaka on the mainland also have to contend with introduced predators and competitors. Predators such as stoats (*Mustela erminea*), ferrets (*Mustela furo*), weasels (*Mustela nivalis*) rats (*Rattus rattus*, *Rattus norvegicus*), dogs (*Canis familiaris*) and cats (*Felis catus*) all pose a threat to native fauna (King 1984). Several aspects of Kaka breeding behaviour make them particularly vulnerable to predators. As hole nesters they nest in deep cavities in tree trunks, making escape from predators difficult (O'Donnell 1996). They have long nesting periods and strong smelling nests which are conspicuous and easily identifiable to predators (Moorhouse 1990, Wilson *et al.*1998). Chicks fledge before they can fly and therefore spend time on the ground (O'Donnell & Rasch 1991, Moorhouse & Greene 1995). These factors mean that nesting female Kaka, eggs, chicks and fledglings are all at risk of predation (Moorhouse 1990, Beggs & Wilson 1991, O'Donnell & Rasch 1991, Wilson *et al.* 1998).

Moorhouse (1990) found that predation of nestlings by Norway rats was a major cause of nesting failure of Kaka on Kapiti Island. Most of the nest failures were in nests within 30 cm of the ground, making them easy targets for Norway rats which have poor climbing ability. On the mainland, Kaka are also at risk from more arboreal predators such as ship rats and stoats. A study of Kaka in the Nelson Lakes region (Wilson *et al.* 1998) found that of 20 breeding attempts monitored over 11 years, only four fledglings survived to independence. Nine young Kaka and four adult females were killed on the nest, most probably by stoats (Wilson *et al.* 1998). Because only adult females incubate eggs, they are at high risk of predation while on the nest, and this subsequently produces a biased sex ratio which further adds to the probability of extinction (Wilson *et al.* 1998).

Kaka are vulnerable to competition from Brush-tailed possums (*Trichosurus vulpecula*) and wasps (*Vespula germanica, V. vulgaris*) for food resources (Beggs & Wilson 1991, O'Donnell & Rasch 1991). In areas throughout New Zealand Kaka numbers decreased significantly with an increase in possum density (O'Donnell & Rasch 1991). There is considerable overlap between possum and Kaka diets, and selective browsing by possums can considerably alter forest composition (Cowan 1990, Owen & Norton 1995). Possum browsing has led to the local extinction of some Kaka foods such as Loranthaceae mistletoes (Ogle & Wilson 1985) and can suppress the production of others such as hinau (*Elaeocarpus dentatus*) fruits (Cowan & Waddington 1990). In addition possums may compete with Kaka for nest holes (Wilson *et al.* 1998) and are potential predators of Kaka eggs and nestlings (Brown *et al.* 1993).

Wasps are a problem in beech forests where they feed on honeydew, one of the few energy rich foods in this habitat, thus reducing the amount available to Kaka (Beggs & Wilson 1991).

1.0.3 Reintroduction as a management tool

In the future Kaka populations will require intensive management to prevent extinction. In addition to the necessary control of introduced predators and competitors (Wilson *et al.* 1998) reintroductions may play an important role in re-establishing Kaka within parts of their former range and counteracting the decline of existing populations.

Reintroductions are being used increasingly in conservation efforts to save many rare and endangered species (eg. Gipps 1991, Serena 1994). A reintroduction usually involves releasing organisms from source populations into apparently suitable, vacant habitat within the specie's historical range. Either captive or wild animals may be used (Scott & Carpenter 1987, Griffith *et al.* 1989). Reintroductions are usually considered successful when a self-sustaining population is established in the wild (Griffith *et al.* 1989). Success can be measured in the short-term from the number of birds that breed successfully after release (Scott & Carpenter 1987).

Translocation has been used as a conservation management tool in New Zealand since at least the 1880s (Saunders 1994). Most translocations have been to offshore islands which are free of the threats present on the mainland, or where any threats can at least be effectively managed (Atkinson 1990, Daugherty *et al.* 1990, Towns *et al.* 1990). For example management of the Kakapo (*Strigops habroptilus*) has involved translocating wild-caught Kakapo to offshore islands where predators and competitors are absent (Lloyd & Powlesland 1994).

Translocations of species into mainland habitat patches have been much less successful than those to islands (Saunders 1994), and have usually been avoided in favour of predator-free islands (Armstrong & McLean 1995). Attempts to re-establish North Island Weka (*Gallirallus australis greyii*), North Island Brown Kiwi (*Apteryx australis mantelli*) and Red-crowned Parakeet (*Cyanoramphus novaezelandiae*) in the Waitakere Ranges between 1976-1986 all failed (MacMillan 1990). All three release examples suffered from high levels of predation and from releasing small numbers of birds. However as techniques developed on islands to effectively control predators and competitors are applied to the management of species in 'island-type' situations on the mainland (Saunders 1990, 1994), reintroductions to mainland sites may become more common in future. Reintroductions of captive-bred individuals, although having severe limitations, can play a useful short-term role in species recovery (Snyder *et al.* 1996) and may also be used more frequently in New Zealand in the future (Saunders 1994, Armstrong & McLean 1995).

1.0.4 Background to Mount Bruce Reintroduction

Reintroductions in the past have often been attempted as 'last-ditch' efforts to save populations which have declined to extremely low numbers (Griffith *et al.* 1989, Saunders 1994). Griffith *et al.* (1989) suggested reintroduction techniques need to be developed as early as possible while a population is large or even increasing in numbers, in case these techniques are required in the future. Because each translocation project is unique, management techniques must be developed to suit each species, and the particular habitat conditions at the release site (Saunders 1994).

Small-scale trial releases are a way to develop such release procedures and monitoring techniques without unnecessarily jeopardizing large numbers of individuals. Trial releases can also provide information on the conditions under which future released individuals can survive, the extent to which pre- or post-release management is necessary, and can generate hypotheses to direct future research and management (Armstrong *et al.* 1994).

Developing techniques for translocating Kaka, and determining the suitability of wild and captive-bred Kaka as release subjects, have been identified as important areas of Kaka research (Captive Breeding Specialist Group 1992). With this in mind a proposal to investigate the feasibility of reintroducing juvenile Kaka to Mount Bruce Reserve in the North Island was developed. Historical records have recorded Kaka as being present in Mount Bruce Reserve up until the 1950s. Welch (1949) in a report to the New Zealand Forest Service wrote that "yellow-fronted parakeets and Kakas are by no means common, but are definitely living and no doubt breeding in the area. I have often observed them and on one occasion saw seven Kakas in one flock". This was the last report of the presence of Kaka in Mount Bruce Reserve.

This project was to initially involve three samples consisting of wild-caught juvenile Kaka from Kapiti Island, captive-bred hand-reared juvenile Kaka, and captive-bred parent-reared juvenile Kaka. In 1995/96 Kaka eggs were also required for a completely separate hand-rearing project undertaken by the Department of Conservation. Eggs from the first clutches of captive Kaka pairs at the National Wildlife Centre (NWC) and Auckland Zoo were sent to Burwood Bush, Te Anau for this project. The resulting Kaka juveniles were returned to Mt Bruce at the projects completion, and these birds became the sample of hand-reared Kaka for release at Mount Bruce Reserve.

The availability of Kaka for the captive-bred parent-reared group depended on the captive Kaka pairs at the NWC and Auckland Zoo re-nesting after their first clutches had been removed. Kaka in captivity had been prevented from breeding in previous years by removing eggs from the nests. This had resulted in the Kaka pairs re-clutching after each removal, and consequently having up to three nesting attempts each season. Because of this previous history of re-nesting after eggs were removed, we assumed that the captive Kaka pairs would re-nest in the 1995/96 season and the resulting chicks would become the sample of captive-bred parent-reared Kaka in the Mount Bruce Release. Sadly nobody thought to inform the Kaka that an entire MSc thesis, not to mention the long-term survival of their species, was dependent on this one simple act of Kaka behaviour, and no re-nesting occurred!

The captive breeding pairs at the NWC and Auckland Zoo redeemed themselves in the 1996/97 breeding season and the resulting group of captive-bred parent-reared Kaka were released in June 1997. The results of this 1997 release are reported elsewhere. This thesis focuses on the initial release in June 1996 of groups of wild-caught juvenile Kaka and captive-bred hand-reared juvenile Kaka (from now on referred to as captive-bred Kaka).

While this project was limited by the small number of birds available for release, it was adequate to trial release procedures and to document post-release behaviour. It is perhaps also a realistic representation of future situations where a minimal number of birds may be available for release attempts.

My involvement in this project consisted of preparing the Kaka for release and monitoring their progress over a six month period after release.

1.1 RESEARCH OBJECTIVES

The aim of this project was to determine the suitability of captive-bred and wild juvenile Kaka as release subjects, and to investigate the techniques needed to successfully release Kaka into a new habitat. I had three objectives in my research:

1. To compare the post-release survival and movements of juvenile captive-bred and juvenile wild-caught Kaka released at Mount Bruce Reserve using a soft release method. This will help uncover the reasons for success or failure of Kaka reintroductions and help refine techniques for future releases of Kaka. Research on this objective is covered in Chapter 2.

2. To investigate the use of supplementary food by juvenile captive-bred and juvenile wild-caught Kaka after their release at Mount Bruce Reserve to determine whether there is a difference between the two groups in feedstation use over time. This research will reveal any positive and/or negative influences post-release feeding has on the Kaka's natural behaviour and their transition to a new environment. Research on this objective is covered in Chapter 3.

3. To compare the post-release behaviour and foraging ecology of juvenile captive-bred and juvenile wild-caught Kaka released at Mount Bruce Reserve in order to learn how they adjust to their new surroundings and new foodstuffs. Research on this objective is covered in Chapter 4.

Chapter 5 summarises the findings of this project, as well as suggesting areas of future research.

1.2 STUDY SITE

Mount Bruce Reserve is an area of podocarp-broadleaf forest east of the Tararua Ranges (Figure 1.1). The north-western boundary of the reserve adjoins State Highway 2 between Eketahuna and Masterton. Mount Bruce Reserve is approximately 1000 hectares in size, and most of this area consists of steep slopes and gullies. The highest point is Bruce's Hill (710 m). Originally Mount Bruce Reserve was part of an extensive podocarp forest known as the "Forty Mile Bush". Mount Bruce Reserve is the last remaining substantial remnant. The rest of the original bush was felled, burned and converted to pasture.

The history of the forest is one of fires, fencing problems, stock trespass and noxious animals, particularly goats (*Capra hircus*), and Brush-tailed possums. Stoats and rats (*Rattus rattus, R. norvegicus*) are also present. Periodic culling of goats within the reserve is undertaken by the Department of Conservation. The Manawatu/Wanganui Regional Council also carry out 1080 poison drops within the reserve to control possums. The most recent 1080 poison drop occurred in June 1994.

Thirteen hectares of mixed exotic species were planted on the north-western side of the reserve in 1933, 1934 and 1951. These species included *Cupressus lawsoniana*, Douglas fir (*Pseudotsuga menziessi*), California redwood (*Sequoia semperveirens*), Spruce (*Picea sitchensis*), Cedar (*Thuja plicata*) and Ponderosa pine (*Pinus ponderosa*).

Mount Bruce Reserve contains many possible food sources for Kaka, particularly: wineberry (*Aristotelia serrata*), tawa (*Beilschmiedia tawa*), marbleleaf (*Carpodetus repanda*), *Coprosma* spp., rimu (*Dacrydium cupressinum*), kahikatea (*Dacrycarpus dacryoides*), hinau (*Elaeocarpus dentatus*), pigeonwood (*Hedycarya arborea*), rewarewa (*Knightia excelsa*), mahoe (*Melicytus ramiflorus*), rata (*Metrosideros robusta*), maire (*Nestegis cunninghamii*), red beech (*Nothofagus fusca*), kaikomako (*Pennantia corymbasa*), tarata (*Pittosporum eugenioides*), five-finger (*Pseudopanax arboreus*), supplejack (*Ripogonum scandens*), pate (*Schefflera digitata*) and kamahi (*Weinmannia racemosa*).

The National Wildlife Centre (NWC) administered by the Department of Conservation is situated on the north-western boundary of the reserve. The Kaka were housed in two aviaries, Aviary 8 and a temporary aviary, at the NWC prior to release (Figure 1.2). The birds housed in Aviary 8 were moved to the temporary aviary at the release site the day before they were released, and all the birds were released from this aviary.

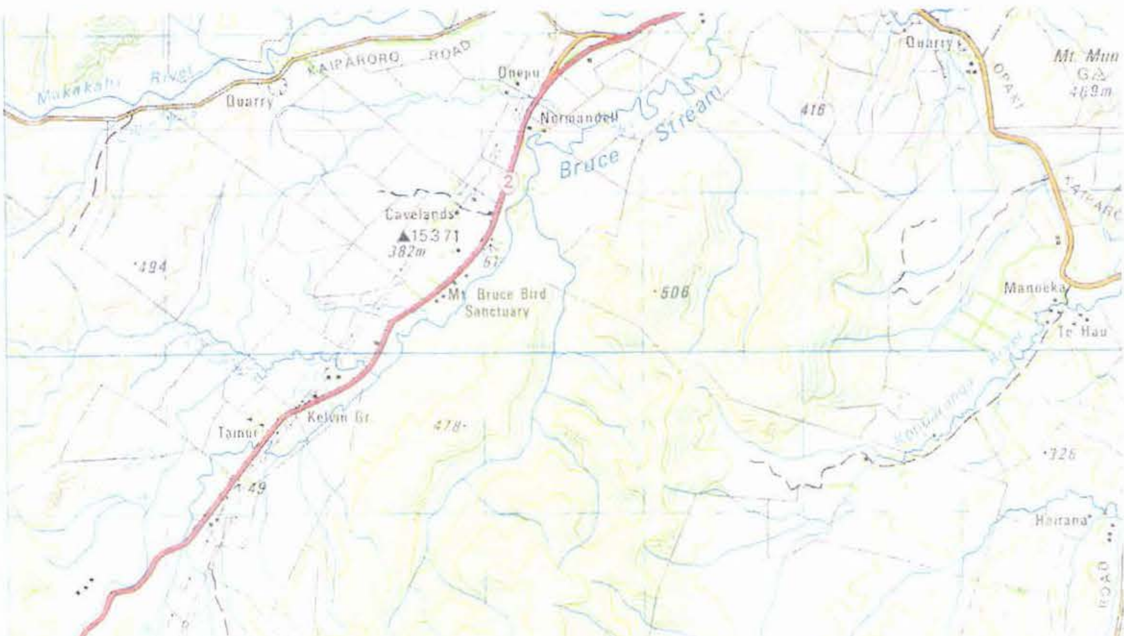

Figure 1.1. Mount Bruce Reserve. Source: New Zealand Topographical Map, NZSM 260.

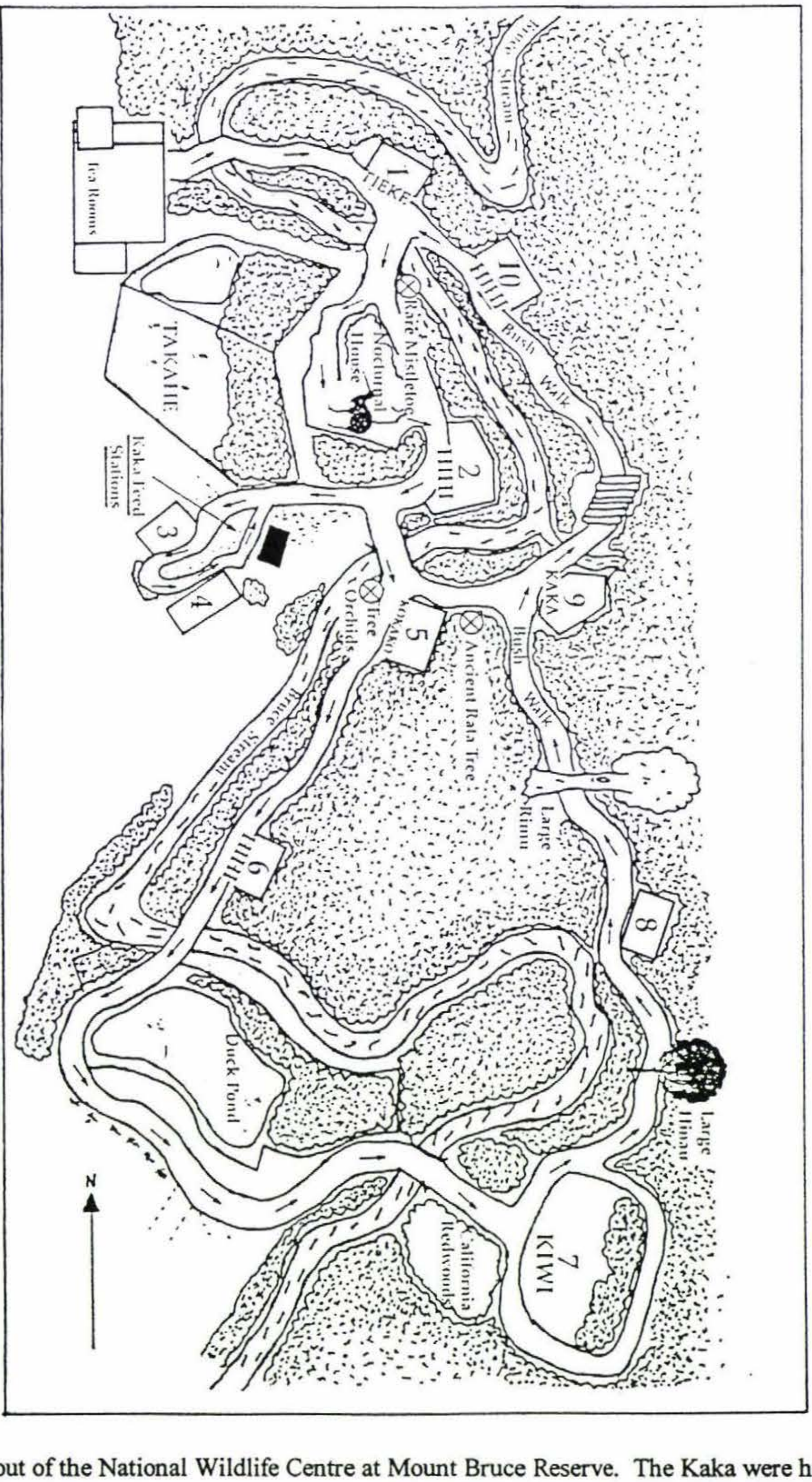

Figure 1.2. Layout of the National Wildlife Centre at Mount Bruce Reserve. The Kaka were held in Aviary 8 and a temporary aviary at the release site (shown by the black square on the map), prior to release. Supplementary feedstations were also set up at the release site.

1.3 RELEASE PROCEDURE

A soft-release method was used, following techniques outlined in Lovegrove & Veitch (1994). Nine juvenile Kaka were released of which four were captive-bred and five were wild-caught. All were 6-8 months old at the time of release. At this age they were independent of their parents (Moorhouse & Greene 1995). The Kaka were named, sexed, and were individually recognizable by colour leg bands (Table 1.1).

Table 1.1. Identification of juvenile Kaka released at Mount Bruce Reserve. M = male, F = female. Birds were sexed from culmen length measurement where length > 44 cm = male (R. Moorhouse, pers. comm.).

Origin	Name	Sex	Bands left-right	Culmen Length mm	Culmen Depth mm	Tarsus Length mm
Captive-bred	Yakka	F	Metal-Yellow	41.2	16.0	34.9
	Bidi	F	Metal-Blue	42.5	16.5	33.0
	Mel	F	Black-Metal	41.9	17.2	35.4
	Burwood	M	Green-Metal	56.8	18.8	37.8
Wild-caught	Te Mimi	M	Red/Black/White-Metal	49.5	19.4	34.7
	Kapiti	F	Metal-Red/White/Green	42.6	16.4	35.3
	Taepiro	M	Red/Blue/Yellow-Metal	44.5	18.4	36.4
	Rangatira	M	Red/Blue/Orange-Metal	44.3	17.9	36.9
	Te Rere	M	Red/Orange/Black-Metal	46.1	18.4	37.6

Preparations for the release involved rearing the captive-bred Kaka juveniles at the NWC. Wild-caught juveniles were caught and held on Kapiti Island then transported to the NWC. All nine Kaka were held for a period of time in aviaries at the NWC, then released and monitored for six months.

1.3.1 Captive-bred Kaka

All four captive-bred Kaka were artificially incubated and hand-reared by Department of Conservation staff in Te Anau, then transferred to the NWC. Two of the Kaka (Yakka and Bidi) arrived at the NWC on 5 February 1996, and the other two (Mel and Burwood) on 3 May 1996. All four Kaka were held together in an aviary at the NWC. The aviary measured 16 m (length) x 9 m (width) x 4 m (height), which allowed enough space for short flights. The aviary was planted with native trees and shrubs representative of the area. An adult Kaka already resident at the NWC was held in the aviary with the juveniles throughout their time in captivity.

While in captivity the captive-bred Kaka were introduced to natural foods obtained from Mount Bruce Reserve. Yakka and Bidi were exposed to a wide range of fruits and berries, including coprosma, pigeonwood, supplejack, mahoe and kaikomako fruits throughout the period they were in captivity from 5 February to 4 June 1996. Because Mel and Burwood arrived at the NWC in May when fewer natural foods were available, and when I was on Kapiti Island, these two birds were exposed to a more limited range of natural foods before release.

1.3.2 Wild-caught Kaka

Five juvenile Kaka were captured using cage traps and mist nets on Kapiti Island over a two week period from 6-17 May 1996. All five birds had yellow eye-rings, and long protruding rachides at the tips of their tail feathers, which are characteristics of juvenile birds (Moorhouse & Greene 1995). Each bird was banded (metal and colour combination), measured (culmen length, culmen depth, tarsus length), sexed, weighed, and fitted with a transmitter (Table 1.1).

The five Kaka were held in an aviary on Kapiti Island for two weeks. The aviary measured 4 m (length) x 2 m (width) x 2 m (height). Wooden perches, foliage, rotten logs and leaf-litter were put into the aviary to make it as natural as possible. The roof of the aviary was covered in foliage to provide extra shelter. The Kaka were provided with food *ad libitum* (corn, apple, pear, carrot, banana, dates, walnuts, cheese, Wombaroo (nectar mix, Wombaroo Food Products, Australia), and sugar water) in feedstations set up in the aviary.

1.3.3 Translocation of wild-caught Kaka to the NWC

The five wild-caught Kaka were translocated from Kapiti Island to the NWC on 17 May 1996. On the morning of the transfer the Kaka were caught in the aviary using hand nets. They were weighed, their transmitter harnesses were checked, and cloacal swabs and faecal samples were collected for disease screening, before the Kaka were put in wooden transport boxes. The boxes measured 550 mm (length) x 300 mm x 300 mm. Each box could house two Kaka in separate compartments. The floor of each compartment was covered in leaves, and the Kaka were supplied with apple and cheese cubes for the journey. Sugar water was supplied for a period of time, but removed from the boxes just before the journey. The birds were transported by boat and car. Upon arrival at the NWC the wild-caught Kaka were immediately released into aviaries with the captive-bred juveniles.

1.3.4 Holding period at the NWC

The nine Kaka were held in two aviaries at the NWC for two weeks to allow the birds to socialise with other individuals prior to release. Five of the Kaka (two captive-bred and three wild-caught Kaka) were held in a large aviary (Aviary 8,

Figure 1.2) with an adult Kaka. The other four Kaka (two captive-bred and two wild-caught Kaka) were held in a small temporary aviary (6 m (length) x 2 m x 2 m) at the release site (Figure 1.2). Both aviaries contained natural foliage, leaf-litter, rotten logs, and perches. Food (based on the diet given to captive Kaka at the NWC) was supplied at feedstations in the aviaries. Natural foods obtained from Mount Bruce Reserve were also provided to the Kaka during this time.

During the two week holding period cloacal swabs and faecal samples were collected from all nine Kaka for disease screening. The samples were screened for coccidia, listeria, salmonella, yersinia and intestinal worm egg counts. All tests returned clear results.

1.3.5 Feedstations

Three feedstations were designed to be set up at the release site (Plate 1.1). Each feedstation consisted of an aluminium circular body divided into four separate feeding compartments (to minimize the chance of aggression between birds, or of one bird dominating a feedstation), and surrounded by pipe for the birds to perch on. Food was supplied in each compartment in bowls (solid foods) and 'hamster' water bottles (liquids). Trays in the bottom of each feedstation caught dropped food, and could be removed for cleaning. Each feedstation was secured 2 m off the ground at the top of a pole by a bolt running through the pole at the base of the feedstation. When the bolt was removed the feedstation could be lowered to the ground for re-stocking with food and for cleaning.

Feedstations were set up in all three aviaries (at the NWC and on Kapiti Island) that housed the Kaka prior to release, so the Kaka could become familiar with feeding from them. On the morning of the release the feedstations were permanently set up at the release site (Plate 1.1).

Plate 1.1. Supplementary feedstation

1.3.6 Transmitters

Transmitters (supplied by Sirtrack Limited, New Zealand) were attached to each of the nine Kaka using a cord harness (Plate 1.2). The transmitter had a pulse rate of 30 beats per minute, with a mortality sensor doubling the pulse rate after a 9.1 hour period of no movement (indicating death or transmitter removed). The maximum lifetime of the transmitters was 11.4 months.

As part of a field trial to investigate methods of identifying individual birds (Moorhouse & Greene 1996), tags were attached to the aerials of some of the transmitters. These tags were either coloured aluminium discs or tubes with a three-colour combination (Plate 1.2).

Transmitters were initially attached to the wild-caught Kaka after capture on Kapiti Island, but had to be removed for repairs to the aerials (some of the Kaka had chewed and bent their aerials) when the birds arrived at the NWC. Repairs consisted of applying heat-shrunk rubber to the transmitter aerials to minimise further damage by Kaka. The transmitters were re-attached on 3 June 1996, the day before the release.

1.3.7 Release

The release took place on 4 June 1996, in the morning. All nine juvenile Kaka were caught the day before the release, weighed, and fitted with transmitters (transmitters were re-attached to wild-caught Kaka). All nine Kaka spent the night in the temporary aviary at the release site. On the morning of the release the front wire was removed from the temporary aviary, allowing the Kaka to fly out.

Plate 1.2. Kaka fitted with a transmitter. Top photo: back view of kaka showing transmitter and aerial tag. Bottom photo: front view of kaka showing positioning of weak link on the transmitter harness. Photos: S. O'Connor.

Chapter 2

Post-release Survival and Movements

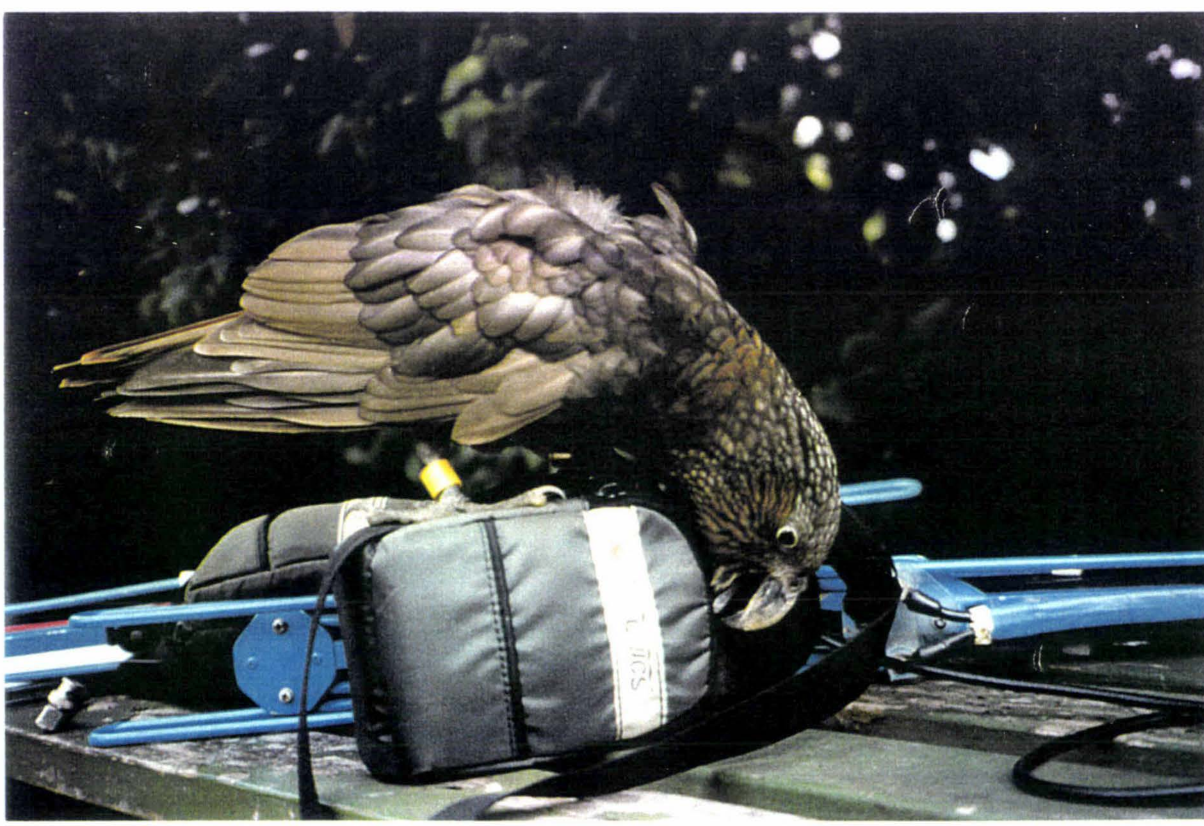

Plate 2.0. Yakka investigating the telemetry equipment. Photo: D. Golder

2.0 INTRODUCTION

The continued existence of a species or population often relies on reintroduction efforts, and the development of appropriate release techniques (Scott & Carpenter 1987, Griffith *et al.* 1989, Wolf *et al.* 1996). The success of a reintroduction can be influenced by factors such as habitat requirements, the size of the release area, the timing of translocations, the size and composition of the founder group and genetic issues (Armstrong & McLean 1995). In addition, the behavioural patterns specific to a species, and to individuals within a species can determine whether a population survives after release (Lyles & May 1987, Kleiman 1989). Obviously it is advantageous to determine which individuals of a species are the most suitable release subjects before valuable time and expense is invested in further release attempts.

A survey by Griffith *et al.* (1989) showed that the success rate of releasing wild-caught birds and mammals was 75% compared to the 38% success rate of releasing exclusively captive-reared animals. Wolf *et al.* (1996) in a follow-up study of the survey by Griffith *et al.* (1989), reported that 71% of reintroductions of wild birds were successful compared to 40% of reintroductions using captive-bred birds, and 54% for reintroductions involving a mix of wild and captive-bred birds.

Experiments with releases of Hispaniolan Parrots (*Amazona ventralis*) and Thick-billed Parrots (*Rhynchopsitta pachyrhyncha*) suggested that translocated wild-caught birds were superior to captive-reared birds in their potential to establish a viable population after release, and that parent-reared birds were superior to hand-reared birds (Wiley *et al.* 1992, Snyder *et al.* 1994). Wild-caught birds had experience at foraging for and handling natural foods, selecting appropriate roost sites and avoiding predators (Wiley *et al.* 1992, Snyder *et al.* 1994). Hand-reared birds seemed reluctant to socialize with wild-caught or captive-bred parent-reared members of their own species (Snyder *et al.* 1989, Wiley *et al.* 1992, Snyder *et al.* 1994), and also typically showed no fear of humans (Low 1984). In releases of hand-reared Thick-billed Parrots (Snyder *et al.* 1989, Snyder *et al.* 1994) deficiencies were observed in the birds' abilities to find food in the wild, their vigilance against raptors, and their interest in joining wild flocks even though the birds had undergone pre-release training to counter such problems. These factors reduced the survival of hand-reared individuals after release and thus their suitability as release subjects.

In New Zealand, the Black Stilt (*Himantopus novaezelandiae*) Recovery Programme is an example of how the origin of individuals can influence the outcome of releases and management options. Since 1981 intensive efforts to increase numbers in the MacKenzie Basin Black Stilt population have included the refinement of multiple clutching, cross-fostering and captive breeding and release techniques (Reed & Merton 1991, Reed & Murray 1993, Reed *et al.* 1993). Initially Black Stilt eggs were fostered to Black Stilt, Pied Stilt (*Himantopus himantopus*) or hybrid pairs. However, there was limited recruitment of juveniles into the breeding population using this technique as chicks fostered to hybrid and Pied Stilts copied the migratory behaviour of their foster parents and did not return to MacKenzie Basin to breed. Subsequently cross-fostering was ceased and management of the Black Stilt concentrated on using only Black Stilt pairs to produce fewer chicks, but ones which had a greater likelihood of being recruited into the population (Reed *et al.* 1993). In the 1980/81 season eight Black Stilt juveniles were hatched and hand-reared in captivity at the National Wildlife Centre before being released at MacKenzie Basin when they were one year old (Reed & Murray 1993). All of the birds were very tame and predator naive, and only one survived for more than one month. In 1986 the captive-breeding programme was moved to MacKenzie Basin within the Black Stilt's natural range. The rationale for this move was that Black

Stilts reared within their natural surroundings and exposed to natural predators would be less predator naive and more able to cope in the wild when released. Further releases of captive-reared Black Stilts occurred between 1987-92. Of the total of 23 birds released, eight survived more than one year (Reed & Murray 1993).

Reintroductions of captive-bred individuals often fail when predation is the main threat to wild populations of the species (Snyder *et al.* 1996). The impact of raptor predation on young and non-breeding Puerto Rican Parrots (*Amazona vittata*) has hampered recovery efforts for this species (Snyder *et al.* 1987, Lindsey *et al.* 1994). From 1979 to 1988, 70 Puerto Rican Parrots fledged from wild nests and three juvenile Puerto Rican Parrots released from captivity were added to the wild population in the Luquillo Mountains, yet the wild population increased by only 11 birds (Meyers *et al.* 1996). Because future recovery efforts will probably require relocation of wild Puerto Rican Parrots or releases of captive-reared parrots (Meyers *et al.* 1996), the predator issue will have to be addressed in order for future releases to be successful.

Predation by exotic predators is an important factor in the decline of most populations of New Zealand bird species (eg. New Zealand Journal of Ecology 1996 volume 20(1), New Zealand Journal of Zoology 1996 volume 23(3)), and has been identified as the major threat to wild Kaka populations (Captive Breeding Specialist Group 1992, Wilson *et al.* 1998). As captive-bred individuals are predator naive (McLean 1997) and have had no opportunities to learn appropriate predator-avoidance behaviours from wild individuals, it can be assumed that reintroduced captive-bred Kaka are at even greater risk of predation than their wild counterparts.

In my study a soft-release method was used to evaluate the suitability of captive-bred and wild-caught juvenile Kaka for use in establishing a new population at a mainland site. In this chapter I investigated three factors, namely post-release survival, site-fidelity and ranging behaviour, which can influence the ability of individuals to form a viable population after release. Post-release survival is obviously important; especially when the founder group is small (as it is in this release), mortalities can be detrimental to the long-term survival of the population. Site-fidelity and ranging behaviours are equally important, as an individual that moves a great distance from the release site is effectively 'lost' from the population in the same way as it would have been through mortality. My aim was to find out whether wild-caught and captive-bred juvenile Kaka released at Mount Bruce Reserve differed in survival, site-fidelity and ranging behaviours after release.

2.1 METHODS

Nine juvenile Kaka were released on 4 June 1996, and I collected data on their survival and movements during the six month period from 4 June to 30 November 1996. Transmitter signals were monitored using a portable receiver (TR4, Telonics, Mesa, Arizona, USA) and hand-held antenna.

I determined whether each bird was within Mount Bruce Reserve by scanning for all signals each day at the release site (Figure 1.1, Figure 1.2). The direction of each transmitter signal was also determined. If I could not pick up a transmitter signal from the release site I scanned the Reserve for the signal from other vantage points. These vantage points were located on ridge tops in areas north-east and south-east of the release site. In addition to scanning for each signal daily, I attempted to track and locate each bird once every seven days, but at times all birds could not always be located. Department of Conservation staff also recorded any sightings of Kaka around the aviaries at the NWC, and sightings by visitors were also noted; these data were included in the results.

I attempted to weigh the Kaka at intervals after release using an automatic weighing machine set up in a feedstation at the release site. Only the captive-bred Kaka stayed on the feedstation long enough to be weighed, and their weights were collected twice after release, on 15 July and 29 November 1996.

I also obtained data on predator sightings and predators trapped around aviaries at the NWC from January 1996 to December 1996 to illustrate the range of predators present in Mount Bruce Reserve during the time the Kaka were released.

2.2 RESULTS

2.2.1 Post-release survival

At least eight of the nine Kaka survived until 30 November 1996 when this study ended. Radio contact with one of the wild-caught birds (Kapiti) was lost on 26 September 1996, 114 days after release. Searches of the Mount Bruce Reserve and areas of the Tararua Ranges were unsuccessful in locating the bird.

The wild-caught Kaka were housed in aviaries with the captive-bred Kaka prior to release without any obvious signs of aggression. However, all birds lost weight during the month they were held together in captivity. Post-release weights for the four captive-bred Kaka increased on average from the pre-release weights (Table 2.1).

Table 2.1. Pre-release and post-release weights of nine juvenile Kaka released at Mount Bruce Reserve in June 1996.

Bird	Sex	Weight (g) 6 May*	17 May**	3 June***	15 July***	29 November***
Yakka	F	-	440	385	434	420
Bidi	F	-	470	375	421	420
Mel	F	-	-	445	-	419
Burwood	M	-	-	530	513	500
Te Mimi	M	480	425	445	-	-
Kapiti	F	500	430	395	-	-
Taepiro	M	520	450	400	-	-
Rangatira	M	440	485	475	-	-
Te Rere	M	600	525	445	-	-
Average		508	461	433	456	440

*weighed on Kapiti Island while in captivity from 6-17 May
**weighed while in captivity at the NWC from 17 May - 3 June
***post-release weights after release on 4 June 1996

2.2.2 Post-release movements of captive-bred Kaka

During the six month monitoring period the four captive-bred Kaka were always located within 1 km of the release site (Table 2.2).

Table 2.2. Movements of wild-caught and captive-bred juvenile Kaka after release at Mount Bruce Reserve in June 1996. Table shows the total distances travelled, the mean distance travelled and the median distance travelled from the release site for wild-caught and captive-bred Kaka each month. W=wild-caught, C=captive-bred.

Month	Maximum distance travelled		Mean distance travelled		Median distance travelled	
	W	C	W	C	W	C
June	800	250	700	130	700	100
July	600	500	533	185	400	100
August	2000	500	627	240	400	200
September	2000	500	385	147	250	150
October	3000	700	680	360	375	375
November	700	500	363	218	400	150

In June the captive-bred Kaka were always located within 200 m of the release site. They were located at the Stitchbird, Kokako and Kaka aviaries by Department of Conservation staff on their feeding rounds (Figure 1.2). Interactions with other Kaka in the aviary were commonly observed, with the newly released Kaka spending time on the roof of the aviary and sometimes coming into contact with the Kaka within the aviary. From July to September and in November the captive-bred Kaka were located a maximum of 500 m from the release site, spending a lot of time feeding in an area of the Reserve above aviaries 8, 9 and 10 (Chapter 4). During October, Yakka, Mel and Burwood were located in an area of the Reserve 700 m south of the release site. Bidi was never located more than 500 m from the release site during the six month monitoring period. Apart from losing radio-contact with Yakka on the 25 and 26 September, I monitored the captive-bred Kaka daily.

2.2.3 Post-release movements of wild-caught Kaka

The wild-caught Kaka were located in areas further from the release site than the captive-bred Kaka during the six month monitoring period (Table 2.2). The movements of each wild-caught Kaka were as follows:

Te Mimi was located 700 m south-east of the release site during the first three weeks after release. In the last week of June Te Mimi returned to the release site. From July to August he was always located within 500 m of the release site. During September, October and November he was located a maximum distance of 800 m from the release site.

Kapiti was located in a group of trees on a neighbouring farm 600 m north of the release site on 7 June (3 days after release). She returned to the Mount Bruce Reserve on 8 June and was always located within 500 m of the release site from

June to early August. Radio contact with Kapiti was lost on 21 August. She was located on 22 August 800 m north of the release site on a neighbouring farm, and returned to the Reserve the next day. She was located within 800 m of the release site during the first three weeks of September. Radio-contact was lost with Kapiti on the 26 September, and she has not been sighted since.

Te Rere dispersed to an area 800 m south of the release site immediately after release. In July he was located in an area above aviaries 8 and 9, 500 m from the release site, and was also located 600 m east of the release site. In August he was located 500 m north-east of the release site, and I also tracked his signal to an area 1 km east of the release site. Radio contact was lost with him on 13 August. In September Te Rere was located at Aviary 9 on the public walkway (Figure 1.2) and at locations in the Reserve 600 m, 700 m, and 1 km south-east of the release site. I also tracked him to an area 1 km east of the release site. Radio-contact with Te Rere was lost on 6-7, 11, 19, 22, 24, and 27-30 September. During October Te Rere was located in areas 500 m east and 700 m south-east of the release site. Radio-contact was lost on 1, 3, 6, 13, 20, 25, 26, 28 and 30 October. During November he was located 500 m north east of the release site, and in an area east of aviary 8 and 9. He was located at the release site on 30 November. Radio-contact with Te Rere was lost on 1-3, 12, 13, 26, and 27 November.

Rangatira moved the greatest distances within Mount Bruce Reserve during the six months. In June I located him 700 m south-east of the release site. During July and August I was unable to locate him at all, but I picked up his signal in areas 1-2 km east of the release site. In September I located him in areas 500 m east, 700 m south-east, 800 m south-east and 1 km south-east of the release site. I lost radio-contact with Te Rere on 6-8, 15, 16, 18, 19, 21, 25, and 27-30 September. I did not locate Rangatira during October, but picked up his signal in areas 1-3 km from the release site. Radio-contact was lost in October for long periods from 1-9, 11-16, 21, 23, 25, 28 and 29 October. In November Rangatira was located 200 m east of the release site and 700 m south-east of the release site. He was located at the release site on 22 November. Radio-contact with Rangatira was lost on 1-3, 12, 13, 26 and 27 November.

Taepiro dropped his transmitter within three days of being released. There were no sightings of him in the Reserve throughout June. He was located in late June in trees near Hokio Beach on the west coast of the North Island by a member of the public, captured, and returned to the NWC at Mount Bruce on 26 June 1996. (Taepiro had already been captured and was being transported back to the NWC before I was informed about it. If he had been left alone it would have been interesting to see if he returned to Kapiti Island). Apart from being very hungry (consuming a lot of food) he seemed in good condition. Taepiro was kept in an aviary at the NWC from 26 June to 28 August. Results from disease screening showed he had tapeworms. He was dosed with Ivomec (Merck Sharp & Dohme Inc. U.S.A.) before being released. Taepiro was re-fitted with a transmitter and released again on 28 August. His weight on 28 August was 410 g, similar to his pre-release weight on 3 June 1996 (Table 2.1). From 28-31 August his signal was picked up 1 km from the release site. On 1 September he returned to the release site and stayed within 200 m of the release site for most of September (and within 50 m of the release site from 1-15 September). Radio-contact with him was lost on 23-25 September. He returned to the release site on 26 September, and remained within 500 m of the release site throughout October and November except for the 22 and 26 of October, and 7, 14, 15 and 26 November when radio-contact with him was lost.

2.2.4 Predators sighted and trapped at the NWC, January - December 1996

During 1996, 33 predators were trapped around aviaries at the NWC, and there were 19 sightings of predators around Mount Bruce Reserve (Table 2.3). Predators sighted and trapped included the Ship rat (*Rattus rattus*), the Norway rat (*Rattus norvegicus*), cats (*Felis catus*), stoats (*Mustela erminea*), weasels (*Mustela nivalis*) and ferrets (*Mustela furo*). The majority of predators trapped were rats followed by cats, stoats, weasels and ferrets. Cats and stoats were the most conspicuous predators in the Reserve, both being sighted on eight occasions. Weasels and ferrets were less conspicuous being sighted on three and two occasions respectively. Only one rat was sighted ranging free in the Reserve (ie. not caught in a trap).

Table 2.3. Predators sighted and trapped at the NWC throughout January - December 1996. T=total, C=caught in a trap, S=sighted.

	Rats			Cats			Stoats			Weasels			Ferrets		
Month	T	C	S	T	C	S	T	C	S	T	C	S	T	C	S
January	1	1	0	2	1	1	0	0	0	0	0	0	0	0	0
February	2	2	0	3	2	1	2	0	2	0	0	0	0	0	0
March	4	4	0	2	1	1	2	1	1	1	1	0	0	0	0
April	1	0	1	4	1	3	2	0	2	0	0	0	3	1	2
May	3	3	0	2	1	1	0	0	0	0	0	0	0	0	0
June	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	3	3	0	0	0	0	1	1	0	0	0	0	0	0	0
September	4	4	0	0	0	0	3	0	3	0	0	0	0	0	0
October	1	1	0	1	0	1	0	0	0	2	2	0	0	0	0
November	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**20**	19	1	**14**	6	8	**12**	4	8	**3**	3	0	**3**	1	2

2.3 DISCUSSION

Deficiencies in the survival skills of release subjects can often hinder efforts to reintroduce rare or endangered species to the wild (Kleiman 1989). My results suggest that there is no difference between captive-bred and wild-caught juvenile Kaka in their ability to establish a population at a new site. However, these results can only apply to Kaka released by the conditions of this study (delayed release, supplementary food provided); the outcome may be different for a situation where alternative release techniques (such as hard release) are used. Because the origin of the released Kaka does not seem to have been a major factor in the outcome of this release, I have considered other aspects of this particular release which may have influenced the birds' survival rates and movements after release.

2.3.1 Post-release survival

Eight of the nine Kaka in my study are known to have survived for six months after release which is a six month survival rate of >88%. This corresponds to an annual survival rate of >78%, indicating that the survival potential of individuals from each group after release is high. Observations of the Kaka after release showed they all seemed fit and well, and were regaining the weight lost during the time spent in captivity.

Survival rates were greater than expected considering rates reported for other recent releases. Nesbitt & Carpenter (1993) reported a 56% (12/27) survival rate for Greater Sandhill Cranes (*Grus canadensis tabida*) 12 months after release. The survival rate for captive-bred European Otters (*Lutra lutra*) one year after release was 42% compared to 79% for wild-caught otters (Sjöåsen 1996). None of the 24 captive-reared juvenile Malleefowl (*Leipoa ocellata*) released into Yathong

Nature Reserve when 3-5 months old survived longer than 104 days (Priddel & Wheeler 1996). Of 12 sub-adult Malleefowl released at the same time when 14-28 months of age, only three survived longer than 428 days. Between 1982-1987 a study carried out by the British Trust for Ornithology compared the survival and dispersal of first year and adult captive-reared Barn Owls (*Tyto alba*) with a sample of wild birds. On average only 10% of the captive-bred birds in their first year and 15% of adults survived, compared with 19% and 55% respectively in the wild population (Cayford & Percival 1992). The causes of mortality in the captive-bred birds were mainly starvation and traffic accidents. In a three year study from 1985 to 1988 minimum survival for 15 juvenile Puerto Rican Parrots from wild nests ranged from 43% to 100% (67% in 1985 (n=3), 100% in 1986 (n=4), 43% in 1987 (n=7) (Lindsey *et al.* 1994). Of three captive-reared juvenile Puerto Rican Parrots released into Luquillo Forest in September 1985 only one survived the first week after release (Snyder *et al.* 1987, Myers *et al.* 1996). However, Maxwell & Jamieson (1997) found that the post-release survival rates of captive-reared Takahe (*Porphyrio mantelli*) released at one year of age compared favourably to the survival rates of wild Takahe of the same age. The survival rates of captive-reared Takahe were 50% in 1990, 88% in 1991, and 50% in 1992, compared to wild Takahe survival rates of 0%, 100% and 60% in the same years. Between 1993/94 100% of both captive-reared and wild Takahe that were monitored survived at least 18 months (Maxwell & Jamieson 1997). Twelve hand-reared Alala (*Corvus hawaiiensis*) were released in Hawaii between 1993-94, with 10 of the 12 surviving at least 19 months after release (Kuehler *et al.* 1995). Brown *et al.* (1994) had a high survival rate for captive-reared Orange-bellied Parrots (*Neophema chryogaster*) released at Melaleuca in south-west Tasmania. Of 25 birds (6 adults and 19 juveniles) released there were only two recorded deaths in the first two years after release.

The high survival rates in my study may be due to aspects of the release procedure, which included a delayed-release method, a supplementary feeding programme, releasing captive-bred birds with wild birds, and releasing birds of a specific age. Fyfe (1977) suggested that gradual release of inexperienced birds allows them to make behavioural adjustments and results in the best survivorship. Pre-release training is also suggested to prepare animals for their new environment (Temple 1977, Kleiman 1989, Derrickson & Snyder 1992, Wiley *et al.* 1992). Pre-release conditioning increased the survival of Mississippi Sandhill Cranes (*Grus canadenis pulla*, Zwank & Wilson 1987) and Bald Eagles (*Haliaetus leucocephalus*, Meyers & Miller 1992) after release. In my study the Kaka were introduced to foods found in the Reserve while in captivity (Chapter 1), so they could become accustomed to identifying and handling them before being released. Supplementary food was also provided post-release to ease the Kaka's transition from captivity to the wild (Chapter 3). Releases of captive-reared Hispaniolan Parrots and Thick-billed Parrots have shown that supplementary food is generally crucial to their survival in the period after release (Wiley *et al.* 1992, Snyder *et al.* 1994). In my study the captive-bred Kaka in particular seemed to rely a lot on supplementary food after release (Chapter 3). Further research is needed to determine whether the Kaka can now survive without supplementary food, and whether it can be discontinued (Chapter 3).

The young age of the Kaka when released may have enabled them to acquire the skills to adapt to, and survive in, a new environment (Armstrong & McLean 1995). While the influence of age on reintroduction success wasn't tested in my study (as all the released Kaka were the same age), results from other releases (Snyder *et al.* 1994, Priddel & Wheeler 1996), have suggested that the age of birds when released is important in ensuring the survival of individuals after release. Between 1986-1993, 88 Thick-billed Parrots were released to the wild in Arizona

(Snyder *et al.* 1994). Groups of exclusively wild-caught adults, exclusively hand-reared adults, and a combination group of parent-reared captive-bred birds and wild-caught adults were released using soft-release methods. In addition, hard releases of groups of wild-caught adults, a hand-reared captive-bred bird and parent-reared captive-bred birds of various ages were carried out. While the adult wild-caught birds exhibited the best survival in the wild, of the captive-bred birds those younger than 20 months survived better than the birds 20 months of age or older. Priddel & Wheeler (1996) found that the age of captive-reared Malleefowl when released influenced their susceptibility to predation by the Red fox (*Vulpes vulpes*). Twenty-four juvenile Malleefowl aged between 3-5 months old and 12 sub-adult Malleefowl aged between 14-28 months old were released into Yathong Nature Reserve. None of the juvenile Malleefowl survived longer than 104 days after release, whereas one third of subadults survived to breeding age (2.5 years) (Priddel & Wheeler 1996). The results from these two studies suggest that each species may have a critical age window for the development of essential survival skills (Snyder *et al.* 1994) and an extended period in captivity before release may impede or enhance this development, depending on the particular species concerned.

While the age of the Kaka when released may have made them more adaptable to a new environment, it also meant that they were less experienced (Armstrong & McLean 1995). The captive-bred Kaka in particular had limited opportunity to learn vital survival skills such as foraging methods and predator avoidance tactics from 'street-wise' wild parents or older wild birds, and could thus be considered predator naive (McLean *et al.* 1994, Maloney & McLean 1996). Releasing the captive-reared Kaka with wild Kaka may have aided their survival. Animals are capable of learning by observation (McLean 1997), and the gregarious nature of the Kaka means the captive-bred birds could have learned important information on coping with predators, and finding natural foods, from the more experienced wild birds (Snyder *et al.* 1989, Wiley *et al.* 1992, McLean 1997). Juvenile Takahe may learn foraging skills by observing their parents' feeding behaviours (Maxwell & Jamieson 1997). Wallace & Temple (1987) found that some juvenile Andean Condors (*Vultur gryphus*) learned what to feed on and how to forage primarily through interactions with other juvenile Condors. For the captive-bred Kaka to have learned from wild-caught Kaka, birds from the two groups need to have interacted after release. The amount of time Kaka spent associating with each other is covered in Chapter 4.

Repairing the habitat so that it is suitable for the species to be reintroduced has been identified as a factor vital to the success of a reintroduction (Berger 1977, Kleiman 1989, Veitch 1994). Usually this means identifying and limiting (eliminating if possible) the factors that caused the endangerment in the first place (Conant 1988, Lyles & May 1987). In the case of Kaka, introduced predators and competitors have been identified as contributing to the decline of wild Kaka populations (Beggs & Wilson 1991, Captive Breeding Specialist Group 1992, Wilson *et al.* 1998), and thus are factors which should be addressed in any reintroduction attempt. In my study supplementary food was provided to the Kaka after release, which would have alleviated the negative effects of competitors. Although stoats, rats, cats, weasels and ferrets were all observed in Mount Bruce Reserve prior to and during the six months of this study, predator control was not a major component of the release, and no predator trapping occurred specifically for the release. However, trapping did occur around aviaries at the NWC as part of the daily management programmes of other species held in captivity at the NWC. No predator-avoidance training of the juvenile Kaka occurred before the release.

Predators have had no impact on the released Kaka so far, and there may be a number of reasons for this. Predation may not be a current limiting factor for Kaka of this age (Soderquist 1994). Previous research has found that Kaka are more at risk from predators at certain ages, namely nesting adult females, nestlings and young juveniles (Moorhouse 1990, Beggs & Wilson 1991, Wilson *et al.* 1998). The Kaka in my study were approximately six months old when released, which a population viability analysis of Kaka (Captive Breeding Specialist Group 1992) has suggested may be an age at which Kaka in general are less susceptible to predators. The released birds also stayed close to the release site at the NWC after release where predator trapping was done, and protection may have been more assured in this area than in other areas of the Reserve.

2.3.2 Site fidelity

It is beneficial to the success of a reintroduction to have reintroduced birds stay near the release site as this increases the chance of individuals finding a mate and breeding successfully. Staying in close proximity to the release site also enables the birds to be monitored effectively and allows them to take advantage of any supplementary food that is provided. How well site fidelity is achieved is often determined by the release method used; either hard release (birds are released to the wild upon arrival at the release site) or soft release (birds are confined to the release site until they become imprinted to the new environment) (Scott & Carpenter 1987).

Releases in Arizona of wild-caught Thick-billed Parrots from Mexico have shown that many individuals will not return to their origin if held in captivity at the release site for some months prior to release (Snyder *et al.* 1989, Snyder *et al.* 1994). Initial attempts at releases of North Island Weka involved the immediate release of wild-caught adult Weka, resulting in the birds moving back towards their former territories after release (Graeme & Graeme 1994). In later releases juvenile Weka were used and local site attachment was fostered in these birds by holding them in captivity at the release site prior to release (Graeme & Graeme 1994).

In my study the captive-bred Kaka showed high site fidelity after being released, whereas the wild-caught Kaka showed less site fidelity. One of the wild-caught Kaka, Taepiro, was found at Hokio Beach on the west coast of the North Island in June 1996, but after being held at the NWC for a longer time period before being re-released, he remained in the Mount Bruce Reserve.

The difference in site fidelity of the two groups may have been due to their origin (captive-bred or wild-caught) and the time they spent at the release site before release. The captive-bred Kaka were held in captivity at the release site for between one and four months, compared to the two weeks prior to release for the wild-caught Kaka. The longer time period that the captive-bred Kaka were held in captivity would have allowed them more time than the wild-caught Kaka to acclimatize to the release site. The captive-bred Kaka were also not subjected to the stressful situation of being translocated from Kapiti Island that the wild-caught Kaka experienced. However, the fact that only one of the wild-caught Kaka travelled a considerable distance from the release site immediately after release suggests that even a holding period of just two weeks may be long enough for most juvenile Kaka to become imprinted to the release area. In addition the young age of the wild-caught Kaka when translocated may have meant they had yet to develop a strong bond with Kapiti Island. The wild-caught Kaka were translocated at the age when they become independent of their parents and move out into new territories. This may therefore be the ideal time to translocate Kaka to completely new environments.

2.3.3 Post-release movements

There were differences in the distances wild-caught and captive-bred Kaka travelled from the release site. Captive-bred Kaka remained close to the release site, whereas the wild-caught Kaka dispersed further within the Reserve, and were also located in areas outside the Reserve for short periods of time. The origin of the Kaka, the time spent at the release site before release and the supplementary feedstations may have all influenced the movements of Kaka after release.

The origin of release subjects has resulted in differences in movement patterns between individuals in other studies. In the case of captive-bred Thick-billed Parrots released into the Chiricahua Mountains in Arizona (Snyder *et al.* 1994), their captive origin had left them ill-prepared for life in the wild and most dispersed aimlessly from the release site immediately after release. Most were classified as mortalities within two months after release due to starvation, raptor predation, or their being re-trapped once it became apparent their chances of survival in the wild were neligible (Snyder *et al.* 1994). By comparison wild Thick-billed Parrots released at the same time initially showed considerable local exploratory movements during the first few months after release, with several movements to locations external to the Chiricahua Mountains, but eventually settled into a restricted and stable range within the Chiricahua Mountains (Snyder *et al.* 1994). Captive-reared Takahe moved greater distances and used different habitats than wild-reared Takahe after release, although neither of these behaviours affected the survival of captive-reared birds (Maxwell & Jamieson 1997).

Other studies of releases of captive-bred animals have reported initial short travel distances and heavy reliance on supplementary food. Captive-reared Andean Condors remained within 1 km of the release site during the first 30 days after release before being encouraged to forage further afield (Wallace & Temple 1987).

Castro *et al.* (1994a) suggested that Hihi (*Notiomystis cincta*) released onto Kapiti Island by the delayed-release method stayed in the areas where they were released because their physical condition was poor and they had access to supplementary food in these areas. Meyers & Miller (1992) found that captive-reared Bald Eagles were more likely to remain near the release site after release than wild-reared eagles. Some of the translocated wild eagles never became accustomed to cages and feeding procedures and may have dispersed from the area sooner than captive-reared eagles because of this (Meyers & Miller 1992).

In my study two of the wild-caught Kaka returned to the release site infrequently and never fed from the feedstations (Chapter 3). These were also the two birds who dispersed the greatest distances from the release site. This suggests the feedstations may have been a cue to keep the Kaka that used them close to the release site.

Bright & Morris (1994) suggested that the shorter distance travelled by captive-bred Dormice (*Muscardinus avellanarius*) was partly due to their inexperience of natural habitats. In my study the captive-bred Kaka may have stayed closer to the aviaries and the feedstations at the release site because they were part of the environment in which they were reared and were thus familiar to them. The adult Kaka kept in captivity in aviaries at the NWC may also have been a factor in keeping the released Kaka in the area. The captive-reared Kaka in particular were often observed around these aviaries and interacted with the Kaka in captivity. Alternatively the wild-caught Kaka had less time to become accustomed to captivity and to the feedstations. The wild-caught Kaka were also subjected to more stress than the captive-reared Kaka while they were being caught and transferred from Kapiti Island into captivity at the NWC. This may have produced a fleeing response in these birds after release.

2.3.4 Summary

Translocated animals can be considered to be established if they stay within the desired release area, survive long enough to reproduce, and are able to integrate into and interact with the new habitat and resident animal populations (Pietsch 1994).

This study has been successful in terms of establishing juvenile Kaka at Mount Bruce Reserve. It has shown that juvenile Kaka exhibit high survival rates and site fidelity after release, making them ideal release subjects. Wild-caught juvenile Kaka translocated to a new site using soft-release methods will generally stay within the release area. Both wild-caught and captive-bred juvenile Kaka when released under certain conditions (supplementary feeding), can survive at least several months after release in the presence of a range of predators and competitors. However, as with most reintroductions, establishing individuals at a new site is only the first step towards achieving a viable population. Therefore this project will be ultimately successful when the released Kaka breed in their new environment.

Chapter 3

Post-release Supplementary Feeding

Plate 3.0. A group of Kaka feeding at a supplementary feedstation. "If heaven drops a date, open your mouth" - *Chinese Proverb*

3.0 INTRODUCTION

Supplementary feeding programmes are recommended for endangered species of birds when the natural food resource is limited, eliminated and/or contaminated (Archibald 1977). Supplementary feeding programmes have been provided for populations of California Condors (*Gymnogyps californianus*), White-tailed Sea Eagles (*Haliaetus albicilla*), Crested Ibis (*Nipponia nippon*) and several species of cranes (Archibald 1977), with varying success (Cade & Temple 1995). In New Zealand supplementary feeding has been included in the management of Kakapo (Powlesland & Lloyd 1992, Powlesland & Lloyd 1994), South Island Kaka (Wilson *et al.* 1991), and Hihi (Castro *et al.* 1994b) specifically to try to induce and sustain breeding.

Supplementary feeding programmes have also become an integral part of many reintroduction experiments (eg. Bright & Morris 1994, Brown *et al.* 1994, Castro *et al.* 1994a, Southgate 1994, Armstrong *et al.* 1997). Providing food at the release site for a period of time after release can ease the transition of released individuals to a new environment, and thus may enhance their survival prospects. In a review of 138 cases where small mammals received supplemental food under field conditions (Boutin 1990), individuals receiving supplemental food usually had smaller home ranges, higher body weights and advanced breeding relative to those on control areas. Boutin (1990) found that the response to food addition appeared to depend on food availability in the natural environment at the time of the experiment, with the greatest response occurring when conditions in the natural environment were poor.

In this chapter I investigated the use of supplementary food by juvenile captive-bred and juvenile wild-caught Kaka for six months after their release at Mount Bruce Reserve, to determine whether there is a difference between the two groups in feedstation use over time. I used allometric equations (Kendeigh *et al.* 1977) to calculate the daily energy requirements of Kaka, and calculated the proportion of daily energy requirements fulfilled by the amounts of supplementary food taken by the Kaka. I predicted that any benefits of supplementary food would be revealed in a bird's daily activity budget. Particularly I predicted that feedstation users would spend less time foraging for natural foods, and consequently more time in other activities. I also investigated whether supplementary feeding influenced the proportions of natural foods feedstation users included in their diets compared to non-users.

Supplementary feeding programmes are expensive and time consuming and also can result in dependency on humans for food. The data I collected on feedstation use over the first six months after release may indicate the amounts of food that should be provided in the future to maintain this Kaka population adequately, and whether or not supplementary feeding can be lessened or eliminated in the future.

3.1 METHODS

3.1.1 Supplementary feedstations

Three feedstations (as described in section 1.3.5) were set up at the release site to provide the Kaka with supplementary food. The feedstations were stocked with food each day. To begin with the feedstations were re-stocked in the mornings and in the afternoon so that there was always food provided throughout the day. As the Kaka began to regularly use the feedstations (from July onwards) the feedstations were only restocked in the late-afternoon to encourage the birds to forage on natural foods during the day, and not rely totally on supplementary food (Wilson *et al.* 1991).

3.1.2 Diet

The post-release supplementary food provided to the Kaka was based on the captive diet given to the Kaka in captivity at the NWC. Initially a range of foods was offered to the Kaka: apple, pear, carrot, banana, kiwifruit, corncobs, sunflower seeds, walnuts, dates, cheese, and jam-water (made from 25 g jam mixed with 400 ml water). During the first month I noticed the Kaka were not eating the banana, orange, kiwifruit and carrot and I stopped providing these food items (Table 3.1).

Table 3.1. Average amounts (g) of supplementary foods provided each day.

Food	Daily amount given (g) in June	Daily amount given (g) from July onwards
Jam	25	25
Dates	50	50
Walnut halves	50	50
Cheese	20	20
Corncobs	200	200
Apples	175	175
Pears	140	140
Sunflower seeds	50	50
Banana	50	0
Orange	25	0
Kiwifruit	40	0
Carrot	50	0

3.1.3 Feedstation Use

I monitored use of the feedstations on a daily basis by recording the presence or absence of each Kaka during a 30 minute period after the feedstations were stocked. I checked the feedstations each day after the Kaka had finished feeding to see which foods they were eating, and how much of each food they had taken.

3.1.4 Daily Energy Requirements

The daily energy requirements of Kaka were estimated from allometric equations (Kendeigh *et al.* 1977, equations 5.73 and 5.74). Equation 5.73 is for the winter season at 0° C where $M=5.908W^{0.05}$ (x 4.197 to convert from kcal to kJ). Equation 5.74 is for the summer season at 30° C, where $M=1.079W^{0.67}$ (x 4.187). For both equations M is kJ per bird per day, and W is weight in grams.

Information on the composition of each supplementary food was obtained from food composition tables (Milligan *et al.* 1988). I used this information to calculate the proportion of a Kaka's daily energy needs obtained from supplementary food.

3.1.5 Activity Budgets

I compared the activity budgets of Kaka using the feedstations to those of Kaka not using the feedstations. I collected activity budget data for each bird over a six month period from June to November 1996 by recording a bird's behaviour at one minute intervals during observation periods lasting a minimum of one hour. Behaviours were categorized as feeding, resting, investigating the environment (all movement not involved with feeding), interactions with other Kaka, and interactions with the observer. I also collected data on natural foods eaten by each Kaka. Foods were categorized as invertebrates, fruits/seeds, flowers, and foliage (leaves, leaf stems, epiphytes, ponga fronds).

3.2 RESULTS

3.2.1 Feedstation Use

Seven of the nine Kaka released at Mount Bruce Reserve were observed using the feedstations during the six months of this study (Table 3.2). All four captive-bred Kaka began using the feedstations on the day of release (4 June 1996). Kapiti was the first wild-caught Kaka I observed using the feedstations. She first fed from the feedstations on 13 June, ten days after release. Kapiti disappeared in September (Chapter 2) and was last observed at the feedstations on 26 September 1996. Te Mimi began feeding at the feedstations on 19 July 1996. Taepiro was not observed at the feedstations throughout June, and it was discovered later that he had moved a considerable distance from the release site immediately after release. He was caught near Hokio Beach on the west coast of the North Island and returned to the NWC on 26 June 1996. He was held in captivity until 27 August 1996 then re-released into Mount Bruce Reserve. Taepiro began visiting the feedstations on 14 September 1996. Rangatira and Te Rere were never observed using the feedstations, although they were present at the feedstation area for the first time in late November (22 November for Rangatira and 30 November for Te Rere).

Table 3.2. Feedstation use by nine juvenile Kaka from June to November 1996, after release at Mount Bruce Reserve on 4 June 1996. Table shows the maximum number of days each month that I monitored the feedstations, and the number of those days that each bird was observed using the feedstations. Percentages of feedstation use by each bird each month are shown in brackets.

	Number of days feedstations visited each month (% in brackets)					
	Month					
	J	J	A	S	O	N
Maximum number of days feedstations were monitored each month	27	31	31	30	31	30
Captive-bred Kaka						
Yakka	22 (81)	31 (100)	26 (84)	28 (93)	28 (90)	28 (93)
Bidi	21 (78)	29 (94)	28 (90)	30 (100)	28 (90)	29 (97)
Mel	21 (78)	29 (94)	27 (87)	30 (100)	28 (90)	30 (100)
Burwood	19 (70)	24 (77)	25 (81)	28 (93)	25 (81)	28 (93)
Wild-caught Kaka						
Te Mimi	0	10 (32)	24 (77)	29 (97)	27 (87)	27 (90)
Kapiti*	12 (52)	20 (65)	23 (74)	21 (70)	0	0
Taepiro**	0	0	0	13 (43)	20 (67)	16 (53)
Rangatira	0	0	0	0	0	0
Te Rere	0	0	0	0	0	0

*Last signal for Kapiti on 26/9
**Taepiro re-released 27/8

The captive-bred Kaka had a higher rate of feedstation use throughout the six months of this study, but both groups used the feedstations least in the first month after release and then increased their use over time (Figure 3.1). Once a Kaka began feeding from the feedstations their use of the feedstations was fairly regular over time.

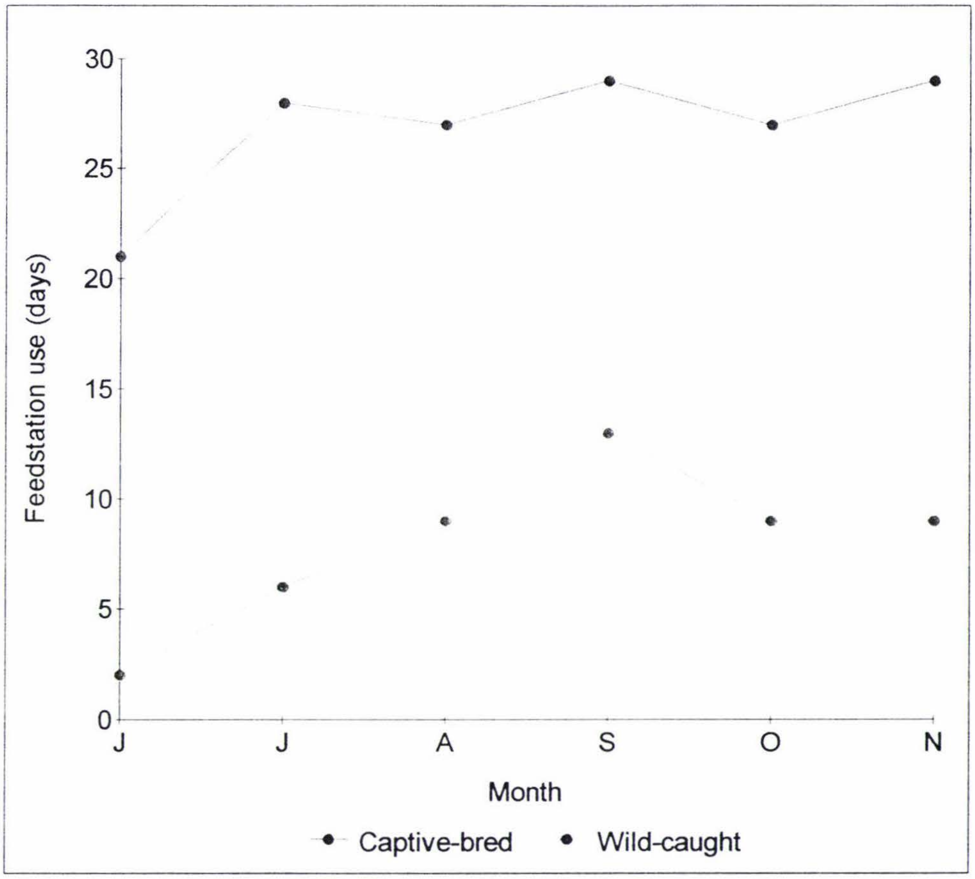

Figure 3.1. Mean number of days per month that captive-bred and wild-caught juvenile Kaka fed from supplementary feedstations after release at Mount Bruce Reserve on 4 June 1996. Months are from June to November 1996.

3.2.2 Daily Energy Requirements

Although seven Kaka were observed using the feedstations during the six months of this study, a maximum of six Kaka used the feedstations each day. The was because Taepiro was re-released and began feeding at the feedstations in mid-September, which was at the same time that Kapiti disappeared and ceased to use the feedstations.

Though the Kaka were initially given a range of foods they ate only the cheese, dates, walnuts and corncobs during the 30 minutes they were observed at the feedstations each day. The Kaka consumed the total amount of all these food items that was provided each day. While the Kaka may have returned to the feedstations later to feed on the other foods provided, they would have faced competition from sparrows and blackbirds which came to the feedstations after the Kaka had left, and basically finished off all food left by the Kaka.

The supplementary foods that the Kaka ate (cheese, dates, walnuts and corncobs) all tended to be higher in protein and fats compared to the other supplementary foods (Table 3.3).

Table 3.3. Composition of supplementary foods available to juvenile Kaka released at Mount Bruce Reserve.

Food	Amount given (g)	Constituents measured as amount per 20 g of food type: Energy kJ	Protein g	Fat g	Carbohydrates g	Fibre g
Jam water	25	218.6	0.12	0.00	13.80	0.22
Pear	140	4102	0.07	0.08	2.36	0.64
Apple	175	39.8	0.06	0.11	2.20	-
Corncob	200	97.8	0.76	0.44	4.37	0.68
Dates	50	207.4	0.40	-	12.78	1.74
Cheese	20	336.6	4.58	6.82	-	-
Walnuts	50	439.4	2.12	10.30	1.00	1.04
Sunflower seeds	50	449.8	4.49	9.80	2.47	1.26
Orange	25	27.6	0.15	-	1.59	0.37
Kiwifruit	40	38.8	0.18	0.12	1.86	-
Banana	60	66.2	0.22	0.06	3.84	0.68
Carrot	50	-	-	-	-	-

Source: Milligan *et al.* (1988)
- data unavailable
Diet from July - December in bold

To determine the amount of energy a Kaka could gain from the supplementary food I based my calculations on the following criteria:

- a maximum of six Kaka used the feedstations each day.
- each of the six Kaka received an equal share of the supplementary food provided.

- calculations are based on the supplementary foods the Kaka ate during each 30 minute observation period, and thus represent the minimum amount of energy a Kaka could gain from supplementary food each day (ie. the Kaka could have returned to feed from the feedstations at a later time).
- an assimilation rate for solid foods of 80% has been calculated for Kaka fed a captive diet (Beggs & Wilson 1987). I assumed that assimilation of jam water would be 100% (Wilson *et al.* 1991).
- I estimated that 20% of the solid foods and jam water would be wasted (Wilson *et al.* 1991). The Kaka tended to drop items of food during feeding when disturbed by other Kaka, and even with only six Kaka present at three feedstations feeding times tended to be chaotic!

I calculated that the minimum kJ/day that a Kaka using the feedstations gained from the supplementary food was 350 kJ/day (Table 3.4).

Table 3.4. Average energy gained per bird per day from supplementary foods.

Food	Daily amount (g) eaten by six Kaka	kJ/amount	kJ/amount less 80% assimilation	kJ/amount less 20% waste	kJ/bird
Dates	50	519			
Walnuts	60	1099			
Cheese	20	337			
Corncobs	200	978			
Solids total	320	2933	2345	1877	313
Jam water (ml)	400	273	-	219	37
TOTAL					350

Using allometric equations for daily energy budgets (DEB) of non-passerine birds, I calculated the DEB for the Kaka (average weight = 432.8 g, n = 9) to be:

$M = 5.908 \times 432.8^{0.05} \times 4.187$

$= 515$ kJ per bird per day in winter and;

$M = 1.079 \times 432.8^{0.67} \times 4.187$

$= 264$ kJ per bird per day in summer.

The Kaka using the feedstations were therefore gaining an approximate minimum of 68% of their daily energy requirements from the supplementary food, assuming winter conditions (0° C). In summer a Kaka could obtain it's daily total kilojoule requirements from the supplementary food.

3.2.3 Activity Budgets

As predicted the Kaka using the feedstations spent less time feeding on natural foods, and more time resting than the Kaka not using the feedstations (Figure 3.2). Kaka using the feedstations spent twice the amount of time resting that non-users did. However the Kaka using the feedstations also spent almost twice as much time moving around investigating the environment than non-users did. This result may be more due to the captive-bred Kaka all being feedstation users than use of supplementary food influencing this behaviour. Because the Kaka using the feedstations tended to congregate in a group this also allowed these birds to spend a proportion of their time interacting with other Kaka.

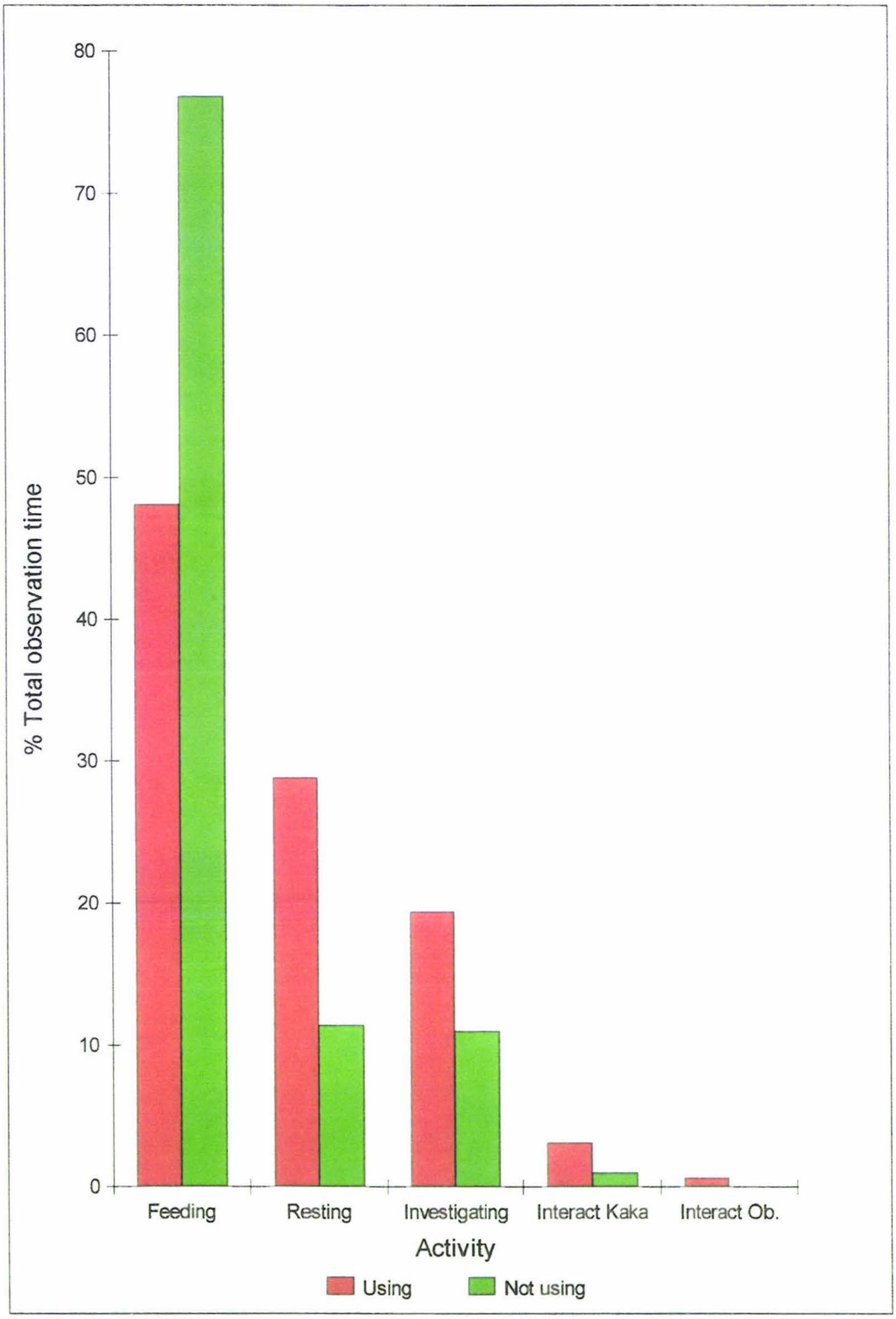

Figure 3.2. Comparison of Activity budgets of juvenile Kaka using, and not using the feedstations after release at Mount Bruce Reserve on 4 June 1996. Using = using the feedstations at least once a month during the six month monitoring period. Not using = never observed at the feedstations during the six month monitoring period. Activities are Feeding, Resting, Investigating the environment, Interacting with Kaka and Interacting with the observer.

3.2.4 Natural Diet

While supplementary feedstation users spent less time feeding, supplementary feeding did not alter the natural diet of the feedstation users considerably from that of non-users (Table 3.5).

Table 3.5. Percentage of foraging time juvenile Kaka using the feedstations and juvenile Kaka not using the feedstations spent foraging on food items in their natural diet.

Food type	Feedstation users % foraging time	Non-feedstation users % foraging time
Invertebrates	86.1	87.7
Fruits/seeds	7.4	11.7
Flowers	0.7	0.6
Foliage	5.8	0.1

Both feedstation users and non-feedstation users spent the greatest proportion of their foraging time foraging for invertebrates. The amount of time feedstation users spent foraging for fruits/seeds was less than for non-feedstation users. Feedstation users on average spent more time foraging on foliage (leaves, leaf stems, epiphytes, ponga fronds) than non-feedstation users. Because all the captive-bred Kaka were feedstation users these differences in diet choices may be due to the origin of the birds rather than the supplementary feeding programme (see Chapter 4).

3.3 DISCUSSION

3.3.1 Benefits of supplementary food

I examined the use of supplementary food by juvenile captive-bred and wild-caught Kaka. I predicted that feedstation users would benefit from supplementary food and these benefits would be reflected in a bird's daily activity budget.

Factors which need to be considered in a reintroduction attempt, such as enhancing survival and breeding, are factors which can be influenced by food supplementation. Previous studies have found that food addition generally results in decreased home ranges, increased body weights, advanced breeding, and increased survival, particularly over winter when conditions may be poor (Jansson *et al.* 1981, Enoksson & Nilsson 1983, Brittingham & Temple 1988, Desrochers *et al.* 1988, Boutin 1990). Brittingham & Temple (1988) compared the survival rates of 418 Black-capped Chickadees (*Parus atricapillus*) having access to supplementary food with those of 158 chickadees without access to supplementary food. The chickadees with access to supplementary food had higher average monthly survival rates, higher over winter survival rates and higher standardized body masses than birds on control sites. The differences in survival between the two groups was most apparent during winter. Brittingham & Temple (1988) suggested that high energy demands during winter made it difficult for birds without access to supplementary foods to obtain sufficient energy from dispersed natural sources. The extra fat carried by individuals that were supplementary fed may also have increased the probability of survival during periods of extreme weather when foraging may have been difficult (Brittingham & Temple 1988).

The amount of time a bird must spend foraging as opposed to other activities depends on the abundance and quality of foods available as well as its requirements

(King 1974). For example, the high energy content of the diet of Crimson rosellas (*Platycercus elegans*) is consistent with the generally small percentage of time spent feeding (Magrath & Lill 1983). Moorhouse (1996) attributed the increase in time spent foraging by Kaka on Kapiti Island from March to June to the nutritional demands of moulting, or decreasing food abundance/quality. O'Donnell & Dilks (1989) reported that sap-feeding by South Island Kaka increased in August when no flower or nectar sources were available, temperatures were lower and energy demands were high. Additionally the availability of natural foods may be affected by competition by other species. Beggs & Wilson (1987, 1988, 1991) in a study of South Island Kaka in the Nelson Lakes region found that Kaka face direct competition for many high energy foods from browsing mammals and wasps.

In my study the supplementary feedstations provided the Kaka with abundant, easily obtained food and this is reflected in the difference between the activity budgets of Kaka using, and not using the feedstations. For Kaka using the feedstations the time spent foraging on natural foods was reduced, and the time spent resting increased. A bird expends least energy when resting (Magrath & Lill 1983, Westcott & Cockburn 1988), so this is a good way to use the time that would have otherwise been spent foraging.

The advantages of supplementary food is also reflected in the food choices made by the Kaka at the feedstations. The Kaka's diet generally consists of plant reproductive products such as nectar, fruits, seeds and pollen, which are considered energy rich (Golley 1961), sap and invertebrates found in the wood of trees (O'Donnell & Dilks 1994, Moorhouse 1996). Invertebrates make up the major component of the Kaka's diet in terms of the amount of time Kaka allocate to foraging for them. While invertebrates are high in protein and fats, a study by Beggs & Wilson (1987) found that the time and energy Kaka invested in collecting certain invertebrates (eg. Kanuka Longhorn Beetle, *Ochrocydus huttoni* larvae) outweighed the nutritional values of the larvae.

During my study the Kaka spent the highest proportion of their foraging time foraging for invertebrates. Then at the end of the day the Kaka using the feedstations favoured the supplementary food equivalents of invertebrates (ie. those highest in proteins and fat). In a general sense it is common sense that the Kaka would go for the supplementary foods with the most benefits. Vickery (1984) found that rodents, when given the choice between two foods that varied in caloric gain per handling time always chose the food items with the highest net energy gain. However, the Kaka may have chosen these particular supplementary foods at the end of the day to top up any deficiencies in their nutritional requirements that were not fulfilled through foraging for invertebrates during the day. Stevens (1985) suggested that the inefficiency of juvenile Starlings (*Sturnus vulgaris*) in foraging for animal prey items resulted in these birds compensating for any shortage by eating cherries which were more accessible. The cherries also contained sugar to provide the birds with immediate energy (Stevens 1985).

I restocked the feedstations in my study each day in the afternoon, primarily to discourage total dependency on the supplementary food (Wilson *et al.* 1991). However, the Kaka using the feedstations may have also benefited from the top-up of supplementary food just before dusk to help get them through the night-time period. Beggs & Wilson (1988) reported that South Island Kaka feed on honeydew (which has a high energy content) mainly in the late afternoon and early morning, and that this may help them to survive through the night and gain energy quickly in the morning. Magrath & Lill (1983) suggested that by foraging immediately before rest periods in the afternoon, Crimson rosellas may exploit the heat produced by feeding and digestion.

The main benefit of the supplementary food was that it provided the Kaka with a stable food source during their transition to an unfamiliar environment. However, the provision of supplementary food did not unduly alter the natural behaviour of the Kaka. All the Kaka still spent a considerable amount of time foraging for natural foods.

3.3.2 Feedstation use

While there were benefits to gain from using the supplementary feedstations the captive-bred Kaka took more advantage of it than the wild-caught Kaka did. The difference between captive-bred and wild-caught Kaka in feedstation use may have been an effect of rearing experience and exposure to supplementary food before the release. Southgate (1994) found that captive-bred Bilby (*Macrotis lagotis*) released at Watarrka National Park remained near the release site after release, and fed on seeds supplied in seed hoppers while wild-bred Bilby did not learn to use the seedhoppers and fed totally on native foods. Zwank *et al.* (1988) suggested that the preference for corn fields by released Mississippi Sandhill Cranes may have been because they were fed shelled corn prior to release. This indicated that captive diets may influence food choice after release (Marshall & Black 1992).

The captive-bred Kaka in my study had been reared on artificial foods and had been feeding from the feedstations for up to four months while in captivity prior to release. They were therefore accustomed to the supplementary food and with feeding from the feedstations. The wild-caught Kaka had less time to become used to feeding from the feedstations, and possibly to recognize the supplementary foods as potential food sources. Although Kaka are provided with supplementary food (cheese and sugar water) daily on Kapiti Island, in a study between March 1991 and January 1992 only one of nine adult radio-tagged Kaka was seen taking this food

(Moorhouse 1996). In another study (Wilson *et al.* 1991), only juvenile South Island Kaka were attracted to supplementary food, suggesting that juvenile Kaka have a neophilic reaction to novel items, and adults a neophobic reaction. Common ravens (*Corvus corax*) also exhibit neophilic behaviour as juveniles, with a shift towards neophobia as they age (Heinrich 1995).

The young age of the Kaka released at Mount Bruce Reserve may have influenced their attraction to novel objects (the feedstations), and the presence and actions of the captive-bred Kaka at the supplementary feedstations may have helped attract some of the wild-caught Kaka to the supplementary food.

3.3.3 Supplementary feeding in the future

The shift from neophilia to neophobia with age shown by South Island Kaka (Wilson *et al.* 1991) and Ravens (Heinrich 1995) suggests that it is possible the two Kaka in my study that never used the feedstations in the six months after release may never be attracted to the feedstations as older birds. This is not necessarily a bad thing - there is no need to encourage dependency on humans for food if the Kaka are capable of surviving naturally in the Reserve. In fact self-sufficiency for all the released Kaka should be a future aim of the project.

It is often difficult to decide when to halt provision of supplementary food while still ensuring the well-being of released individuals (Kleiman 1989), but it is a necessary action to take for total rehabilitation to the wild. Often release subjects make the decision themselves, such as the case when Thick-billed Parrots were released into the wild in Arizona (Snyder *et al.* 1989, Snyder *et al.* 1994). Two groups of wild-caught adult Thick-billed Parrots were released using soft-release methods in September 1986 and October 1986 respectively. The group released in September 1986 visited the release cages daily for the first month to drink from bowls on the cage tops, but once they discovered natural drinking sources their visits to the cages became infrequent and brief. The group released in October 1986 immediately joined and adopted the current roosting and drinking behaviour of the group released earlier and never developed a daily pattern of returning to the cages for water. A further group of wild-caught adults released in 1987 were also initially dependent on water at the release cages, but switched to natural water sources after about one month (Snyder *et al.* 1994). On the other hand, the reintroduction of hand-reared Alala in Hawaii involved providing supplementary food in two feedstations placed 10 m and 25 m from the release aviary (Kuehler *et al.* 1995). The supplementary food was slowly reduced over a 3-5 month period, and the weights and behaviour of the birds was monitored during this time. However the young Alala continued to feed at the supplementary feedstations throughout this period, and did not disperse from the release site until supplementary feeding was completely discontinued.

In my study there was no decrease in the use of supplementary food by the Kaka over time, indicating that they will feed on supplementary food for as long as it is provided. However, use of supplementary food does not necessarily mean that it is needed. The fact that two of the wild-caught Kaka survived in Mount Bruce Reserve for six months without using the feedstations suggests that, at least for wild-caught Kaka, prolonged supplementary feeding after release may not be necessary. More research is required to determine whether the Kaka (and the captive-bred Kaka in particular) could cope with reductions or termination of the supplementary feeding programme in the future. This could involve further reduction of the number and amounts of foods provided, and/or providing food less often, and monitoring how the Kaka cope with the changes.

Armstrong *et al.* (1997) carried out such an experiment to test whether a population of Hihi on Mokoia Island was limited by natural food supply.

Supplementary food was provided to the Hihi on an alternating basis each month, and the Hihi were weighed at the end of the periods when food was available and unavailable. Weight loss during periods when supplementary food was absent was used as an indirect assessment of starvation, and thus an indication that food supply was limiting to Hihi's survival on Mokoia Island.

While the NWC is situated at Mount Bruce Reserve making long-term supplementary feeding of the released Kaka possible, future releases of Kaka may be to areas where such resources are not available for a prolonged period of time. Therefore it is important to know whether captive-bred Kaka can convert totally to a wild situation, and survive indefinitely without human help. The release of Kaka into Mount Bruce Reserve could be considered to be most successful if the Kaka become totally self-sufficient, but in saying this there may also be certain times of the year when natural foods are scarce, or higher nutritional demands on the Kaka (such as breeding and rearing chicks) could be aided by supplementary feeding.

3.3.4 Other considerations

Aside from the direct value of feedstations to the Kaka, the feeding programme may provide other benefits. If continued in the future it may provide a way of incorporating released birds into the established population at Mount Bruce Reserve and keeping released birds in the release area. Groups of up to 40 wild and captive-bred Orange-bellied Parrots released into the wild between 1991-93 regularly fed together at supplementary feeders with no apparent aggression (Brown *et al.* 1994), suggesting that the feeders significantly assisted in the rapid assimilation of captive-reared birds into the wild population. (However there was no control in this release, so the parrots may have assimilated into the wild population just as easily without the feeders). The feedstations also aided post-release monitoring (Brown *et al.* 1994). Because Hihi released onto Kapiti Island in 1991-92 learned to feed from feedstations, these became ideal sites from which to monitor the survival of the birds following release (Castro *et al.* 1994a). In my study the feedstations also proved to be an ideal site to carry out daily monitoring of the released Kaka. In the future the site may be the most suitable area for recapturing the Kaka when transmitters need to be replaced, or medical checks need to be carried out. Finally, the supplementary feeding programme provided an excellent opportunity for the general public to see Kaka at close range and learn about their needs - an important consideration as public support is vital to the success of this, and any future releases.

Chapter 4

Post-release Behaviour

Plate 4.0. Kaka feeding on flax flowers.

4.0 INTRODUCTION

An animal's survival ultimately depends on its behaviour. Because of this, monitoring of behaviour is an important consideration in reintroductions (Lyles & May 1987, Soderquist 1994, Beissinger 1997). It can indicate how well release subjects are adapting to free-range conditions, or to a new habitat, and can determine the appropriateness of certain groups (captive-bred or wild animals) for reintroduction.

To survive an individual must be skilled at avoiding predators, finding food, and interacting appropriately with the environment (Kleiman 1989, Clemmons & Buchholz 1997). Juveniles of many species are slow to learn such essential skills (Burger 1988, Wunderle 1991). For parrots in general, essential skills in foraging and predator avoidance are acquired over time, and in some cases by extensive and lengthy social contact (Diamond & Bond 1991, Stoleson & Beissinger 1997). Captive environments differ greatly from wild environments, and may limit the extent to which captive-bred animals can learn certain behaviours before release (Kleiman *et al.* 1994, Beissinger 1997, Clemmons & Buccholz 1997). Some deficiencies in the behaviour of captive-bred animals are obvious, such as predator avoidance behaviour (McLean *et al.* 1994), but others may be more subtle, only becoming apparent when captive animals are moved from the security of the captive environment to the wild. As any limitations in the survival abilities of captive-bred and wild birds decrease their suitability as release subjects, it is important that these limitations are identified through post-release monitoring and remedied before further releases occur (Scott & Carpenter 1987).

My aim in this chapter was to compare the post-release behaviour and foraging ecology of juvenile captive-bred and juvenile wild-caught Kaka to determine how well they adapted to their new surroundings and new foodstuffs.

4.1 METHODS

Behavioural data were collected for nine juvenile Kaka over a post-release period of six months, from June to November 1996. Observations were made during the daylight hours of 9am-6pm. Beggs & Wilson (1991) found that Kaka are active from at least 30 minutes before sunrise to 30 minutes after sunset, and other parrot species have been shown to roost between sunrise and sunset (Magrath & Lill 1983, Westcott & Cockburn 1988). I assumed that during this study roosting would occur between sunset and sunrise and no observations were made during this time. Individual birds were located using telemetry equipment, and then watched for up to two hours. Minimum observation time was set at one hour for each observation period. I attempted to collect behavioural data from each bird in each month, but sometimes I was unable to locate all the birds in some months. Over the six month period I observed the captive-bred Kaka for a total of 4483 minutes, and the wild-caught Kaka for a total of 3571 minutes.

4.1.1 Activity Budgets

I used an instantaneous sampling method (Altmann 1974, Martin & Bateson 1986), with a one minute sampling interval. I observed a single bird during each observation period. On each sample point I recorded the time, the bird's behaviour and the bird's location within the forest structure (categorized as either the tree species or ground). I also recorded whether other Kaka were in the area (ie. within my visual range) during each monitoring period.

I recorded five behavioural categories:

1. Feeding: included all observations of manipulating and ingesting natural food items.

2. Resting: included all incidences of sitting and roosting, as well as maintenance behaviours such as preening, scratching and stretching.
3. Investigating the environment: included all movement except that which was associated with feeding.
4. Interactions with other Kaka: any interactions between two or more birds.
5. Observer interaction: any contact with the observer.

I used ANOVA to test whether the amount of time Kaka spent feeding (as opposed to the amount of time spent in other activities) varied between captive-bred and wild-caught Kaka, and between months. The feeding data was collected as a proportion of the total time budget and then transformed by arcsine-square root transformation for analysis (Martin & Bateson 1986). I used a nested design where individual birds were nested under captive-bred or wild-caught categories. The statistical level was set at 0.05 and the test was two-tailed.

4.1.2 Foraging Ecology

I collected data on foraging ecology simultaneously with the other behavioural data. One bird feeding on one food type at one sampling point during an observation period constituted one feeding record. For each feeding record I recorded the bird, the time, the month, the food type, and the bird's location within the forest structure (categorized as either the tree species the bird was feeding in, or the ground).

Types of food were categorized as invertebrates (Kaka extract the invertebrates in the wood and bark of trees, R. Moorhouse *pers. comm.*), fruit/seed, flowers, foliage (including all leaves, leaf stems and epiphytes) and unidentified.

Intake rates of fruits/seeds were measured by counting the number of fruits a bird consumed in one minute.

4.2 RESULTS

4.2.1 Social Behaviour

While being observed the Kaka were within visual range of other Kaka an average of 49% (range 10% - 78%) of the time (Table 4.1).

Table 4.1. Percentage of observation time juvenile Kaka were observed within visual range of other Kaka.

	Captive-bred Kaka				Wild-caught Kaka				
	Yakka	Bidi	Mel	Burwood	Te Mimi	Kapiti	Taepiro	Rangatira	Te Rere
% of time with other Kaka	62	61	78	53	62	60	41	13	10

Seven of the Kaka (all four captive-bred Kaka and three of the wild-caught Kaka) were frequently observed close to each other (Table 4.2). These seven Kaka also used the feedstations at the release site throughout the six months they were monitored (Chapter 3), and moved the least distance from the release site after release (Chapter 2). Two wild-caught Kaka, Rangatira and Te Rere moved greater distances from the release site after release (Chapter 2), and were most often observed alone. I first observed these two Kaka interacting with the other seven Kaka in November, at the end of the six month monitoring period.

Table 4.2. Percentage of total observation time juvenile Kaka spent within range of each other. Total observation times (minutes) are: Yakka 1153, Bidi 1185, Mel 1002, Burwood 1143, Te Mimi 1054, Kapiti 786, Taepiro 486, Rangatira 531, Te Rere 714.

Observed Kaka	% Time spent within range of each other Kaka in area								
	Yakka	Bidi	Mel	Burwood	Te Mimi	Kapiti	Taepiro	Rangatira	Te Rere
Yakka	-	27	22	29	22	25	0	0	0
Bidi	37	-	20	20	26	25	0	9	0
Mel	49	31	-	39	22	22	0	0	0
Burwood	34	33	46	-	14	14	0	0	0
Te Mimi	10	13	22	27	-	28	7	0	0
Kapiti	37	30	16	24	36	-	0	0	0
Taepiro	21	29	12	21	4	0	-	0	0
Rangatira	0	13	0	0	0	0	0	-	0
Te Rere	10	10	10	10	10	10	10	10	-

Social interactions occurred mainly between the seven Kaka that remained close to the feedstations and release site (Table 4.3, Table 4.4). These interactions included conciliatory behaviours such as allo-preening and approaching a Kaka and touching beaks. I observed a variety of agonistic behaviours such as chasing and displacing, and play-fighting. Play-fighting behaviours included lunging at another Kaka, play-biting, foot clawing, flapping wings and kicking. The Kaka would frequently hang acrobatically from branches, and were very vocal while engaged in play-fighting behaviour.

I observed both Burwood and Te Mimi trying to mount Mel, although all attempts were unsuccessful. Burwood was also observed investigating hollows in trees on two separate occasions in October. A further incident was reported by a member of the public on 6 November, of three Kaka on the roof of Aviary 9 "practising to mate"!

Two of the nine Kaka (Yakka and Bidi, both captive-bred) interacted with me while I was observing them. There were also four incidences reported of Yakka and Bidi landing on members of the public at the NWC throughout the six months of this study.

Table 4.3. Number of interactions between juvenile Kaka released at Mount Bruce Reserve. Initiator and recipient totals for each bird are in brackets.

	Recipient								
Initiator	Yakka (20)	Bidi (17)	Mel (52)	Burwood (23)	Te Mimi (37)	Kapiti (12)	Taepiro (14)	Rangatira (2)	Te Rere (1)
Yakka (42)	-	7	9	7	11	5	3	0	0
Bidi (9)	3	-	2	1	0	1	0	2	0
Mel (20)	2	1	-	10	4	2	0	0	1
Burwood (39)	5	0	23	-	6	0	5	0	0
Te Mimi (37)	10	3	10	4	-	4	6	0	0
Kapiti (23)	0	1	6	0	16	-	0	0	0
Taepiro (5)	0	2	2	1	0	0	-	0	0
Rangatira (3)	0	3	0	0	0	0	0	-	0
Te Rere (0)	0	0	0	0	0	0	0	0	-

Table 4.4. Social interactions observed between juvenile Kaka released at Mount Bruce Reserve.

Interactive Behaviour	Percentage of total occurrences (number of occurrences observed in brackets)
Allo-preening	35 (62)
Beak touching	18 (32)
Chasing/displacing	17 (31)
Play-fighting	22 (38)
Mountings	8 (15)

The captive-bred Kaka spent more time on the ground than the wild-caught Kaka (Table 4.5).

Table 4.5. Percentage of total observation time individual juvenile Kaka were observed on the ground.

	Captive-bred Kaka				Wild-caught Kaka				
	Yakka	Bidi	Mel	Burwood	Te Mimi	Kapiti	Taepiro	Rangatira	Te Rere
% time spent on ground	15	12	4	8	4	0	0	0	0

4.2.2 Activity Budgets

There was variation between the activity budgets of the captive-bred and wild-caught groups of Kaka, and also among the activity budgets of individual birds (Figure 4.1, Figure 4.2). All the wild-caught Kaka spent most time feeding, followed by resting and investigating the environment (Figure 4.2). All the captive-bred Kaka also spent most time feeding (Figure 4.2). For two of the captive-bred Kaka (Yakka and Bidi) investigating the environment was the second most commonly occurring activity, followed by resting. For Burwood and Mel resting was the second commonest activity followed by investigating the environment (Figure 4.2). All Kaka interacted with other Kaka, but for both groups interactions made up only a small percentage of their total activity budgets (Figure 4.1, Figure 4.2).

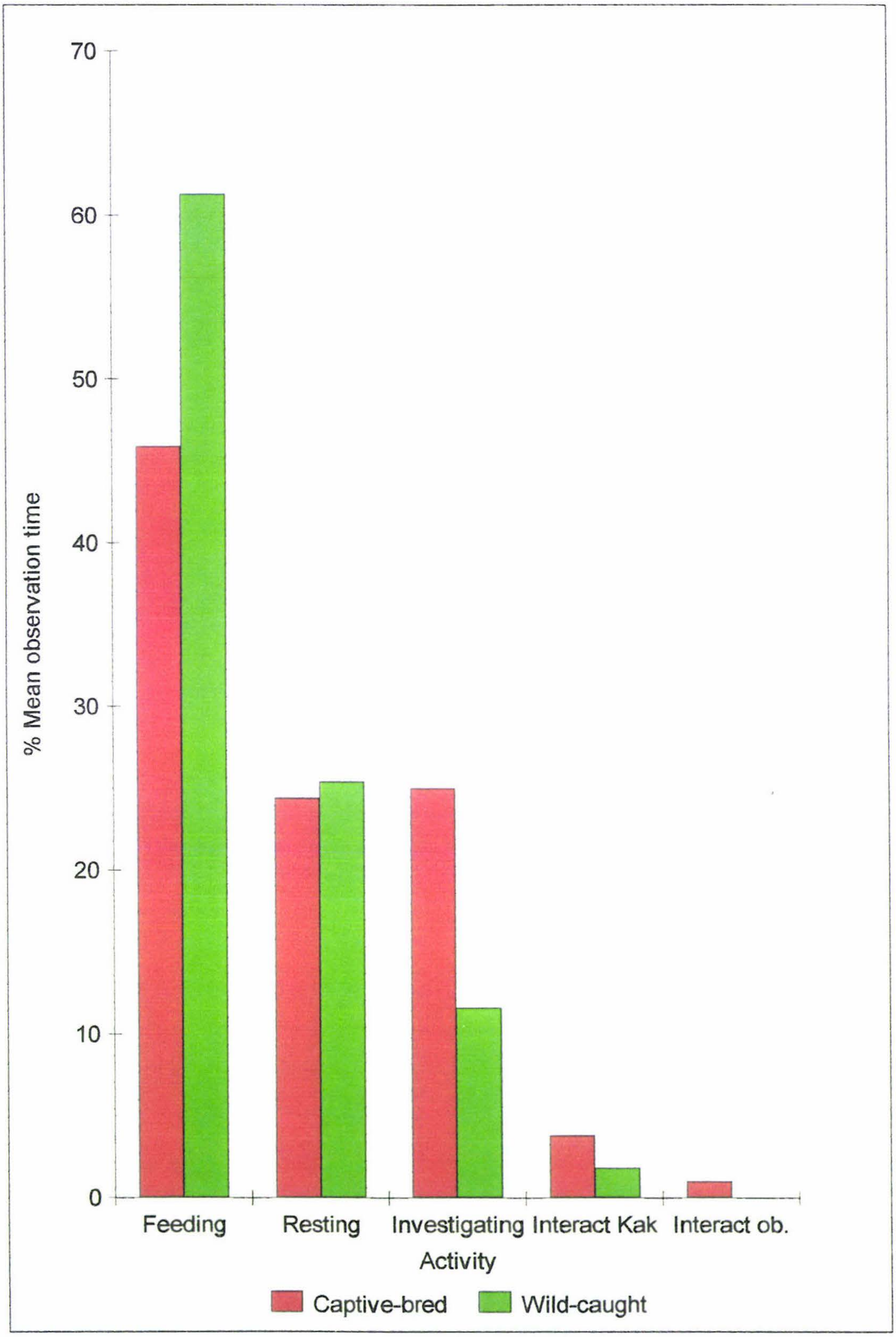

Figure 4.1. Comparison of Activity budgets of captive-bred and wild-caught juvenile Kaka observed over six months after release at Mount Bruce Reserve in June 1996.
Activities are: Feeding, Resting, Investigating the environment, Interactions with Kaka, Interactions with the observer.

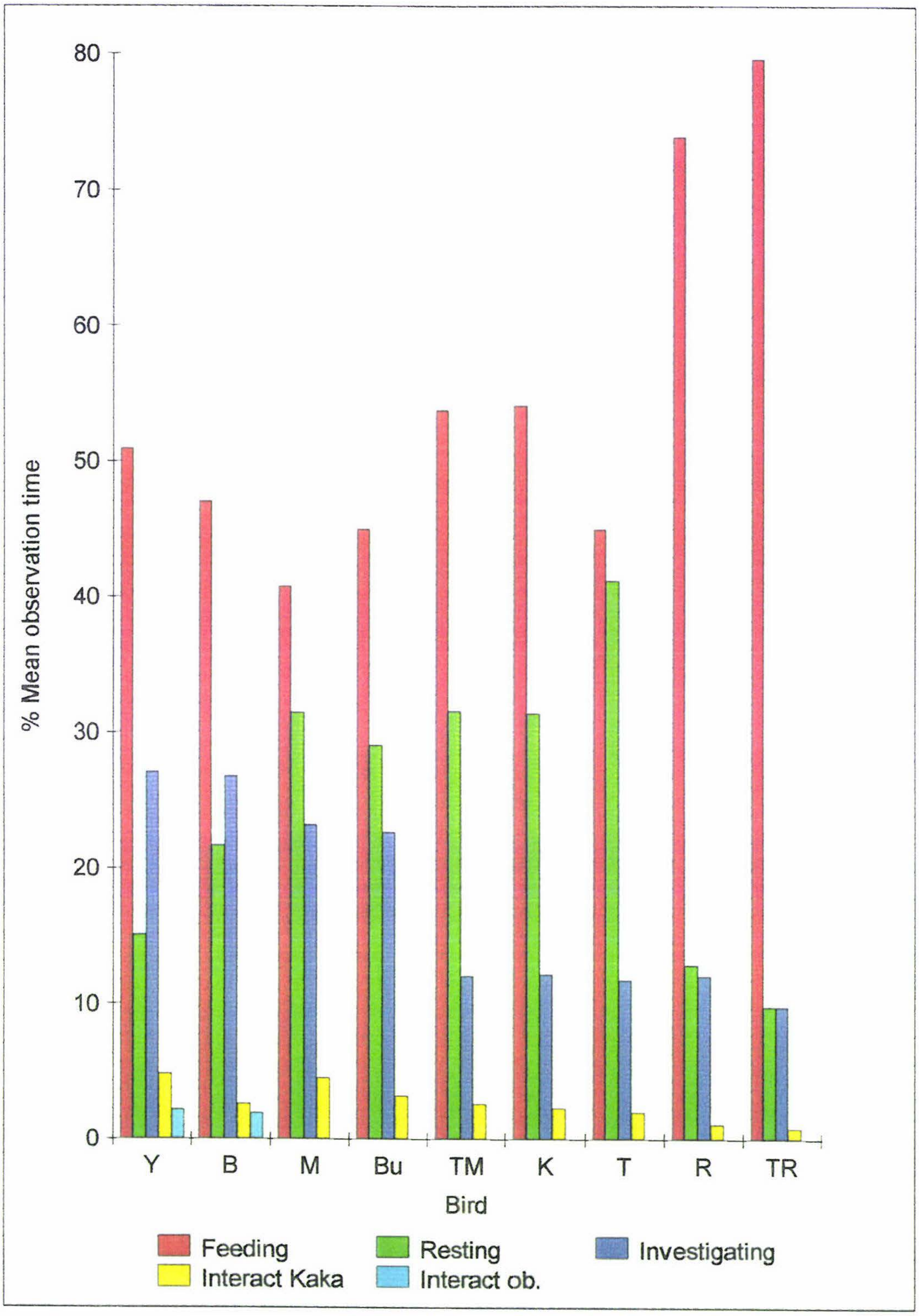

Figure 4.2. Comparison of Activity budgets of nine juvenile Kaka observed over six months after release at Mount Bruce Reserve in June 1996. Activities are: Feeding, Resting, Investigating the environment, Interactions with Kaka, Interactions with the observer. Birds are: Y = Yakka, B = Bidi, M = Mel, Bu = Burwood (all captive-bred), TM = Te Mimi, K = Kapiti, T = Taepiro, R = Rangatira, TR = Te Rere (all wild-caught).

The amount of time spent feeding as opposed to other activities was significantly different between captive-bred and wild-caught groups, in that captive-bred Kaka spent less time feeding than wild-caught Kaka (Table 4.6). Subsequently the amount of time captive-bred Kaka spent investigating the environment was greater than for wild-caught Kaka. Both groups spent the same amount of time resting (24.4% for captive-bred Kaka and 25.4% for wild-caught Kaka, Figure 4.1), and spent similar amounts of time interacting (3.8% for captive-bred Kaka and 1.8% for wild-caught Kaka, Figure 4.1).

Table 4.6. ANOVA test to test whether the amount of time spent feeding varied between captive-bred vs. wild-caught juvenile Kaka, and between months. Individual birds were nested under captive-bred vs. wild-caught categories. CvsW = captive-bred vs. wild-caught. Data were transformed by arcsine square-root transformation.

Source	SS	DF	MS	F	P
Bird	1.1853	7	0.1693	6.1454	0.0001
CvsW	0.2415	1	0.2415	8.7661	0.0054
Month	0.0304	1	0.0304	1.1050	0.3002
Error	0.9920	36	0.0276		

The amount of time both captive-bred and wild-caught Kaka spent investigating the environment was greatest in June, then decreased over time. As time spent investigating the environment decreased, time spent feeding and resting increased (although time spent feeding did not differ significantly over months (Table 4.7).

Table 4.7. Amount of time (a) captive-bred juvenile Kaka and (b) wild-caught juvenile Kaka spent in each activity each month. Months are from June - November 1996.

	Month					
Activity	J	J	A	S	O	N
(a) Captive-bred Kaka						
Feeding	41.8	36.4	43.9	45.4	51.7	55.6
Investigating environment	36.2	33.8	27.3	24.8	16.3	14.5
Resting	15.6	23.6	22.9	25.6	29.1	27.2
Interactions	6.4	6.2	5.9	4.2	2.9	2.7
(b) Wild-caught Kaka						
Feeding	66.4	56.8	59.6	54.4	66.9	63.9
Investigating environment	19.8	14.7	15.9	7.1	4.6	7.2
Resting	13.8	25.2	21.6	37.4	26.6	27.5
Interactions	0.0	3.3	2.9	1.1	1.9	1.4

4.2.3 Foraging Ecology

The nine Kaka were observed feeding on a wide range of food types (Table 4.8, Table 4.9), but spent most of their foraging time searching for, and extracting, invertebrates from the wood and bark of trees. While the Kaka invested a lot of time in foraging for invertebrates I observed only one of the birds (Te Mimi) extracting larvae of a substantial size (>1 cm) from a tree. Te Mimi spent 20 minutes nibbling the bark of a Hinau (*Elaeocarpus dentatus*) and during this time extracted and ate three larvae (probably Huhu, *Prionoplus reticularis*, beetle larvae). The wild-caught Kaka tended to concentrate their feeding efforts on invertebrates and fruits/seeds, whereas the captive-bred Kaka were all observed feeding on a range of additional foods (Table 4.8, Table 4.9). These additional foods included leaves, leaf stems, ponga fronds, and epiphytes.

Table 4.8. Percentage of observation time captive-bred juvenile Kaka spent feeding on each food type. Total observations for each bird are as follows: Yakka = 587, Bidi = 557, Mel = 370, Burwood = 514.

Food type	Kaka Yakka	Bidi	Mel	Burwood	Total Captive-bred
Invertebrates	91.0	87.7	76.3	82.3	84.4
Fruits/seeds	1.3	6.1	5.4	10.5	5.9
Flowers	0.5	0.0	4.1	0.2	1.2
Foliage					
Leaves	0.3	1.1	1.6	0.6	0.9
Leaf stems	1.4	0.7	1.1	1.8	1.2
Epiphytes	0.3	0.9	5.4	1.6	2.1
Ponga fronds	4.9	3.1	6.2	3.1	4.3
Total foliage	6.9	5.8	14.3	7.1	8.5
Unidentified	0.0	0.4	0.0	0.0	0.1

Table 4.9. Percentage of observation time wild-caught juvenile Kaka spent feeding on each food type. Total observations for each bird are as follows: Te Mimi = 566, Kapiti = 425, Taepiro = 120, Rangatira = 407, Te Rere = 568.

Food type	Kaka Te Mimi	Kapiti	Taepiro	Rangatira	Te Rere	Total Wild-caught
Invertebrates	85.9	91.3	88.3	79.9	95.4	87.9
Fruits/seeds	9.6	7.5	10.8	20.1	3.3	10.1
Flowers	0.0	0.0	0.0	0.0	1.1	0.2
Foliage						
Leaves	0.2	0.7	0.0	0.0	0.0	0.2
Leaf stem	0.0	0.5	0.8	0.0	0.2	0.3
Epiphytes	0.7	0.0	0.0	0.0	0.0	0.1
Ponga fronds	3.7	0.0	0.0	0.0	0.0	0.7
Total foliage	4.6	1.2	0.8	0.0	0.2	1.3

The amount of time Kaka spent feeding on each food type varied between months (Table 4.10, Table 4.11). Fruits (identified as Hinau, Maire, Kahikatea and Supplejack berries) were consumed in the greatest amounts in June by both captive-bred and wild-caught Kaka. The amount of foraging for invertebrates increased from August to November, as foraging on fruits/seeds decreased. The consumption of foliage by captive-bred Kaka was greatest in June and then decreased over time. The wild-caught Kaka spent less time overall than the captive-bred Kaka feeding on foliage, and the wild-caught Kaka consumed this mainly in the first three months after release (Table 4.10, Table 4.11).

Table 4.10. Variation between months in consumption of each food type by captive-bred juvenile Kaka.

	Month					
Food type	J	J	A	S	O	N
Invertebrates	62.2	82.5	90.2	88.1	92.9	89.4
Fruits/seeds	18.1	3.6	6.3	6.3	1.4	0.0
Flowers	0.0	0.0	0.2	0.0	1.8	5.3
Foliage						
Leaves	1.0	2.5	0.4	0.7	0.0	0.0
Leaf stems	2.6	1.4	0.2	1.4	1.6	0.0
Epiphytes	0.3	5.3	0.9	2.1	0.0	1.1
Ponga fronds	15.1	3.9	1.8	1.4	2.3	4.2
Total foliage	19.0	13.1	3.3	5.6	3.9	5.3

Table 4.11. Variation between months in consumption of each food type by wild-caught juvenile Kaka.

	Month					
Food type	J	J	A	S	O	N
Invertebrates	58.7	86.4	95.5	91.1	100.0	95.8
Fruits/seeds	39.7	6.8	1.9	8.5	0.0	2.2
Flowers	0.0	0.0	0.0	0.0	0.0	1.5
Foliage						
Leaves	0.9	0.0	0.0	0.2	0.0	0.0
Leaf stems	0.6	0.0	0.0	0.0	0.0	0.5
Epiphytes	0.0	0.0	1.1	0.0	0.0	0.0
Ponga fronds	0.0	6.8	1.6	0.2	0.0	0.0
Total foliage	1.5	6.8	2.7	0.4	0.0	0.5

I observed the Kaka feeding in 29 species of tree, and they fed on a range of food types from most of these tree species (Table 4.12).

Table 4.12. Percentage of observation time nine juvenile Kaka spent feeding in tree species. Foodtypes fed on by Kaka: I = invertebrates, L = leaf, LS = leafstem, PF = ponga frond, E = epiphyte, F = flowers, FS = fruits/seeds, UN = unidentified.
Months fruits/seeds consumed: J = June, Ju = July, A = August, S = September, O = October, N = November, TY = throughout year, D = dropped fruits/seeds scavenged from ground throughout year. - = never observed feeding on fruits/seeds.

Tree species	% of total feeding observation time	Food types	Months fruits/seeds consumed
Nestegis cunninghamii (Maire)	16.0	I,L,LS,F,FS	J,Ju,D
Elaeocarpus dentatus (Hinau)	14.2	I,E,FS	J,D
Coprosma spp.	10.3	I,L,LS,E,F,FS	A (green fruits)
Pseudopanax arboreus (Fivefinger)	7.7	I,LS,FS	S
Weinmannia racemosa (Kamahi)	6.8	I,E	-
Carpodetus serratus (Marbleleaf)	4.9	I,LS,FS	A,S
Dead trees	4.8	I	-
Cyathea spp., *Dicksonia* spp.	4.1	PF,E	-
Exotics	3.8	I,F	-
Aristotelia serrata (Wineberry)	3.6	I,L	-
Beilschmiedia tawa (Tawa)	3.1	I,L,LS,E	-
Melicytus ramiflorus (Mahoe)	3.0	I	-
Dacrycarpus dacrydioides (Kahikatea)	2.6	I,LS,FS	J
Schefflera digitata (Pate)	2.0	I,LS	-
Nothofagus fusca (Red beech)	1.6	I,E	-
Pennantia corymbosa (Kaikomako)	1.5	I	-
Knightia excelsa (Rewarewa)	1.5	I,F	-
Ripogonum scandens (Supplejack)	1.2	LS,L,FS	TY
Prumnopitys ferruginea (Miro)	1.1	I,E	-
Dacrydium cupressinum (Rimu)	0.8	I	-
Cordyline australis (Cabbagetree)	0.7	I,L	-
Pittosporum tenuifolium	0.7	I	-
Unidentified	0.7	I,L,LS,FS,UN	D
Pittosporum eugenioides (Tarata)	0.6	I,L,LS,FS	N
Phormium tenax (Flax)	0.2	F	-
Metrosideros spp. (Rata vines)	0.1	L	-
Myrsine australis (Mapou)	0.1	I	-
Metrosideros robusta (Rata)	0.05	I	-
Solanum aviculare (Poroporo)		0.02	LS -
Ground	2.3	I,L,FS,UN	D

I observed the four captive-bred Kaka and one of the wild-caught Kaka (Te Mimi) feeding on the ground (Table 4.13).

Table 4.13. Percentage of observation time juvenile Kaka spent feeding on the ground.

	Captive-bred Kaka				Wild-caught Kaka				
	Yakka	Bidi	Mel	Burwood	Te Mimi	Kapiti	Taepiro	Rangatira	Te Rere
% time observed feeding on ground	4	3	2	4	4	0	0	0	0

A comparison of intake rates for captive-bred and wild-caught Kaka shows that the wild-caught birds consumed more fruits per minute than the captive-bred birds, although a small amount of data was collected (Table 4.14).

Table 4.14. Comparison of fruit/seed intake rates for captive-bred and wild-caught juvenile Kaka.
*observation from a single bird.
- no data collected.

	Intake rates (fruit/seeds per minute)	
Fruit/seed type	Captive-bred Kaka	Wild-caught Kaka
Pseudopanax arboreus	2*	5*
Elaeocarpus dentatus	0.3*	1.75 (range = 1-2.3, n=3)
Ripogonum scandens	1*	1.6 (range = 1.3-1.8, n=3)
Nestegis cunninghamii	1.15 (range = 0.95-1.5, n=3)	2.2 (range = 1.4-3, n=2)
Dacrycarpus dacrydioides	-	1.5*
Carpodetus serratus	1.5*	1*
Pittosporum eugenioides	-	1.7*
Phormium tenax (flowers)	5*	-
Unidentified	1.1*	1.8*

4.3 DISCUSSION

4.3.1 Social behaviour

Individual Kaka were commonly observed within the vicinity of other Kaka, indicating that there was a high degree of sociality for seven out of the nine Kaka. The four captive-bred Kaka most frequently spent time with each other. However, they also spent time near, and interacted with, three of the wild-caught Kaka. The captive-bred Kaka may have particularly benefited from this association with more experienced birds.

While Moorhouse (1996) observed little social interaction between North Island Kaka on Kapiti Island, other parrot species commonly flock together and interact, especially when feeding (Magrath & Lill 1983, Cannon 1984, Magrath & Lill 1985, Snyder *et al.* 1987, Westcott & Cockburn 1988, Diamond & Bond 1991, Brown *et al.* 1994, Snyder *et al.* 1994, Garnett & Crowley 1995). Garnett & Crowley frequently observed Hooded Parrots (*Psephotus dissimilis*) feeding among flocks of Black-faced woodswallows (*Artamus cinereus*), and suggested that they used the woodswallows as sentinels to alert them to predators.

Protection from predators is one of the benefits of forming a group (Westcott & Cockburn 1988). However, of even greater benefit to the captive-bred Kaka would be the ability of wild-caught birds to provide information about the location and appearance of food resources (Wunderle 1991). The captive-bred Kaka may also have acquired foraging techniques by observing the behaviour of the more experienced wild-caught birds (Sherry & Galef 1984, Palameta & Lefebvre 1985, Sherry & Galef 1990). Cannon (1984) suggested that large-sized feeding flocks of Eastern rosellas (*Platycercus eximius*) may be important in ensuring the survival of young birds over their first winter. A young bird would learn the location of suitable foraging areas more rapidly in a group than if it foraged alone. Young Takahe may learn foraging behaviours by observing their parents (Maxwell & Jamieson 1997). Young Nene (*Branta sandvicencis*) learn important social and foraging skills from their parents, particularly dominance behaviours while feeding and vigilance against predators (Marshall & Black 1992). Consequently, captive-reared birds raised in the absence of parent birds do not acquire these skills, and in some cases are considered less suitable release candidates. Juvenile Andean Condors learn what to feed on and how to forage through interactions with parents and other juveniles (Wallace & Temple 1987). Because Condors rely heavily on the behaviours of other Condors to locate foods, it is vital for translocated and captive-bred birds to socialize with other Condors after release.

Being in a group also enabled the Kaka to partake in a variety of social interactions including conciliatory behaviours (allo-preening), agonistic behaviours (chasing/displacing, play-fighting), and sexual behaviours (mountings). Interactions involving play or sexual behaviour have also been observed between fledgling and juvenile Kea (*Nestor notabilis*, Diamond & Bond 1991). Both Kaka and Kea do not reach sexual maturity until four years of age (Moorhouse & Greene 1995). Levinson (1980) suggested that such social interactions as those exhibited by the released Kaka (especially social play) might be important in increasing social ties between juveniles, as well as introducing and developing certain adult behaviours. Predator-proof nest boxes will be put up at Mount Bruce Reserve in the coming year in anticipation of future breeding attempts.

The relatively high levels of gregariousness shown by the released Kaka may also help in future releases to rapidly integrate released individuals or groups into the established flock at Mount Bruce Reserve. Initial releases of Thick-billed Parrots involved a soft-release method (Snyder *et al.* 1989, 1994), but more recent releases of wild-caught birds have simply involved transporting them to the location of the wild flock and releasing them immediately; these birds have immediately joined the wild flock.

The time captive-bred Kaka spent on the ground was relatively high compared to reports from other studies. O'Donnell & Dilks (1994) reported that South Island Kaka spent 0.1% of total feeding observations feeding on the ground. It is rare for North Island Kaka on Kapiti Island to spend time on the ground (R. Moorhouse, *pers. comm.*). Wiley *et al.* (1992) identified the tendency of captive-reared Hispaniolan Parrots to search for food on the ground as a risky foraging behaviour making these birds susceptible to predators. Magrath & Lill (1983) suggested that immature Crimson rosellas may be more at risk of predation than adults because of their inexperience, and because they fed on the ground more often. Two recorded deaths of juvenile Kaka in Whirinaki Forest were also probably due to being preyed on by predators while feeding on the ground (Close 1996). Bahama Parrots (*Amazona leucocephala bahamensis*) on Abaco Island nest in limestone cavities in the ground, making them vulnerable to predation by feral cats (Gnam 1990, Gnam & Burchsted 1991,Gnam 1994).

It remains to be seen whether the captive-bred Kaka in my study are more at risk from predators than the wild-caught Kaka because of the greater amount of time they spend on the ground. The fact that the released Kaka are feeding on the ground could also make them at risk to poisoning from 1080 baits. Captive-bred Kaka which are already familiar with an artificial diet, and which investigate all novel food items that they encounter, may be especially vulnerable. Hickling (1997) conducted a trial which investigated whether the use of green dye and cinnamon on cereal bait would deter captive-bred North Island Kaka from feeding on them. All three captive-bred Kaka involved in the study fed on both plain and treated baits, although they ate much more plain bait than treated bait over the course of the experiment (Hickling 1997). These results, and the behaviour of the Kaka released into Mount Bruce Reserve, should be taken into account when planning future poison drops in the Reserve area.

4.3.2 Activity Budgets

A major difference between the activity budgets of individual Kaka, and between groups of captive-bred and wild-caught Kaka was the amount of time spent feeding on natural foods. The difference in the amount of time spent foraging was inversely related to the amount of time Kaka spent investigating the environment. This difference can be attributed, in part, to the origin of the bird (captive-bred or wild-caught) and to variability in feedstation use by the nine Kaka. The two wild-caught Kaka (Rangatira and Te Rere) who never used the feedstations spent a considerable amount of time feeding on natural foods (74% of observation time for Rangatira and 80% for Te Rere). North Island Kaka on Kapiti Island (Moorhouse 1996) and South Island Kaka (Beggs & Wilson 1991) also spend the majority of daylight hours foraging. For the four captive-bred Kaka and three wild-caught Kaka that used the feedstations, time spent foraging for natural foods was reduced, in some cases by up to 40%. It can be presumed that these birds were under less pressure to obtain natural food than the two Kaka not using the feedstations. Powell & Cuthbert (1993) found that Killdeer (*Charadrius vociferus*) chicks reared in captivity also spent less time feeding compared to wild Killdeer chicks. They suggested that this behaviour was an artifact of captivity where food was supplied constantly.

The amount of time captive-bred Kaka spent feeding was less than that for wild-caught Kaka, but captive-bred Kaka spent more time moving around investigating the environment than wild-caught Kaka. As part of their development young birds are initially curious of their surroundings and explore the environment by pecking at both appropriate and inappropriate items (Wunderle 1991, Heinrich 1995). With time and experience they are able to recognize edible foods and eventually concentrate their attentions on these items. For example young Ravens follow their parents, and at first show interest in all items that they encounter (Heinrich 1995). Once they learn to distinguish food from non-food, they pay limited attention to most non-rewarding items. Heinrich (1995) suggested that the initial interest shown by young Ravens in all items allows them to learn the background element of their environment so they can quickly locate new sources of food. This initial exploratory behaviour is also important when the Ravens disperse from their parents to new environments. They can use previous experiences to quickly find appropriate food resources in their new surroundings. Rare items which were previously not encountered are most likely to receive more scrutiny (Heinrich 1995).

The amount of time that the released Kaka spent feeding as opposed to investigating the environment may have been due to their previous experiences with natural environments. The natural environment on Kapiti Island is probably very similar to the environment of Mount Bruce Reserve. The wild-caught Kaka would have been familiar with the forest environment, and could use their previous experience on Kapiti Island to locate food resources within Mount Bruce Reserve quickly. When the captive-bred Kaka were released they were entering a totally new environment to the one that they were reared in. This is reflected by the greater amount of time they spent investigating the environment, as opposed to feeding, and by the fact that their exploration decreased over time, probably as the environment became more familiar to them.

The greater amount of time that the captive-bred Kaka spent investigating the environment suggests that immediately after release the captive-bred birds were still learning to identify and locate food resources. They were thus perhaps less efficient foragers than the wild-caught Kaka at this stage.

4.3.3 Foraging Ecology

Components of foraging include searching time, capture time, handling time and ingestion of food (Burger 1988). It is generally accepted that juveniles are less proficient than adults in one or all of these components because of their inexperience (Wunderle 1991). For example the high mortality of juvenile Hooded Parrots may partly be due to their lack of feeding skills at this age (Garnett & Crowley 1995).

In addition, previous reintroductions (Kleiman *et al.* 1991, Snyder *et al.* 1994) have shown that for certain species captive-bred individuals are more inept foragers than their wild counterparts, making their transition to the wild difficult, or even impossible.

In my study both captive-bred and wild-caught Kaka fed on a variety of natural foods, even though two of the captive-bred Kaka (Mel & Burwood) had limited or no exposure to some natural food items prior to release (Chapter 1). Considering the broad natural diet of Kaka (O'Donnell & Dilks 1994), Moorhouse 1996) and the fact that juvenile Kaka in the wild are foraging independently from their parents at six months of age (Moorhouse & Greene 1995), it is not surprising that the wild-caught Kaka had no problems adapting to the new environment of Mount Bruce Reserve. The wild-caught Kaka were reared in a similar environment to Mount Bruce and they would have already learned some foraging skills from their parents.

The diverse natural diet of the captive-bred Kaka after release suggests that they were learning by trial-and-error to recognize potential food items in the new environment (Wunderle 1991, Heinrich 1995). This is supported by the fact that the

Kaka narrowed their diet choices over time, both in terms of the variety of food items they fed on, and the time they spent feeding on each item.

A positive finding of this study is that, unlike other species such as Mississippi Sandhill Cranes (Zwank *et al.* 1988), the habituation of captive-bred Kaka to a captive diet during rearing did not unduly affect the ability of these Kaka to forage on a range of natural foods when released. However, this result is not altogether surprising as early preferences can often be over-ridden by future experience (McLean 1997). For example Kaka held permanently in captivity at the NWC are provided with natural foods when they are available, and in most cases prefer these foods as well as, or more than, their usual captive diet (*pers. obs.*). Behavioural development also occurs over time, with a juvenile bird's later foraging proficiency in part depending on what was learned in earlier stages (Wunderle 1991). In an experiment by Rojek & Conant (1997) Nene goslings reared on an exclusively captive diet accepted native berries just as readily as goslings exposed to these berries from day of hatching. However Rojek & Conant (1997) found that captive Nene that were reared to adulthood on a limited diet did not readily accept novel berries. This means that although the captive-bred Kaka were not disadvantaged from being exposed to a limited range of natural foods before release, it is still advantageous to provide captive-bred Kaka with a wide variety of food as early as possible. This early exposure is a platform on which future skills can be developed, and may mean the Kaka are able to recognize potential food sources more quickly after release it they have had previous experience of them. Also, while the exploration by captive-bred Kaka after release shows they are capable of searching for their own food, it does not mean they were efficient at finding it or handling it.

Unfortunately the constant supply of supplementary food to the captive-bred Kaka, while being necessary after release, may have masked or compensated for any deficiencies in their searching abilities which would have otherwise been revealed by the poorer condition, or higher mortality rate of these birds (not that we wanted any of the birds to drop dead just to find this out!).

Another factor influencing juvenile diet selection is their limited handling abilities. Juveniles have been found to be less adept at handling food items than adults. They tend to drop food items more frequently than adults and have longer handling times than adults (Wunderle 1991). In addition, studies of Thick-billed Parrots (Snyder *et al.* 1989, Derrickson & Snyder 1992), showed wild birds were more efficient at handling food items than captive-bred birds, and parent-reared captive-bred birds were more efficient than hand-reared birds. It took Thick-billed Parrots months to become expert in pine-cone husking whether they fledged in captivity or in the wild (Wiley *et al.* 1992). However parent-reared captive-bred Thick-billed Parrots learned more quickly how to open the pine-cones than hand-reared conspecifics (Snyder *et al.* 1989, Derrickson & Snyder 1992).

In my study intake rates of fruits/seeds were greater for wild-caught Kaka than captive-bred Kaka indicating that the wild-caught Kaka may have been more adept at handling food items than the captive-bred birds. Improvement in juvenile handling time and ability can largely be attributed to learning and to maturation (Wunderle 1991), so the intake rates of both captive-bred and wild-caught Kaka will probably increase as they gain more experience. This highlights the importance of enabling captive-bred Kaka to have experience at handling a variety of foods as early as possible before release so they can practise and develop these techniques. Rojek & Conant (1997) found that while Nene goslings reared on a captive diet were curious of, and pecked at all novel berries they did show a preference for certain ones. They appeared to choose berries that were easiest to handle (ie. berries that were large and conspicuous, fell off branches easily, and ones with skins that ruptured easily so they were easier to remove and eat). Nene goslings that had been reared on a diet including a variety of native berries, and were thus experienced at handling all the types, seemed to choose between berries on account of their taste, rather than the ease of handling them (Rojek & Conant 1997).

The diversity of the released Kakas' diet and the large amount of time they spent foraging for invertebrates is consistent with observations of other North Island and South Island Kaka populations (O'Donnell & Dilks 1994, Moorhouse 1996). As I only saw one of the Kaka (Te Mimi) eating larvae of a large size (and this was only one occasion out of many observations), this suggests that the Kaka were mostly finding only small invertebrates. The Kaka would thus have had to forage for a long time on invertebrates to eat enough to fulfill their daily requirements.

The intake of specific foods at certain times of the year (for example hinau fruits in June), with a subsequent decrease in time spent foraging for invertebrates during these times, is also consistent with findings from other studies. North Island Kaka on Kapiti Island (Moorhouse 1996), South Island Kaka in South Westland (O'Donnell & Dilks 1994) and other parrot species (Long 1984, Lindsey *et al.* 1991, Garnett & Crowley 1995) change their diets frequently, generally dictated by the changing availability of individual foods. Foraging for invertebrates is relatively inefficient (Beggs & Wilson 1987) so it is sensible for Kaka to switch to alternative food sources when they are available.

O'Donnell & Dilks (1994) suggested that the Kaka's omnivorous and seasonally flexible diet and wide range of foraging techniques have allowed them to adapt to modifications in their habitat, while more specialist species (for example Huia, *Heteralocha acutirostris*) have become extinct. These same characteristics may also allow Kaka to adjust quickly to new environments after translocation. However such a broad diet means a Kaka must become proficient at many foraging techniques, and it takes time to develop these skills. Monitoring after release is thus essential to see how well the Kaka adapt to their new environment.

4.3.4 Summary

The aim of this chapter was to compare the post-release behaviour and foraging ecology of juvenile captive-bred and juvenile wild-caught Kaka to determine how well they adapted to their new environment after release. The high degree of socialization between captive-bred and wild-caught Kaka after release was a positive result in that it may have assisted in the learning of vital foraging and predator-avoidance skills through interactions with each other. Both wild-caught and captive-bred Kaka identified and fed on a range of natural foods after release, indicating that both groups had little difficulty making the transition to a new environment. However, the constant supply of supplementary food after release may have masked or compensated for any foraging deficiencies that the captive-bred Kaka in particular may have had. Because the captive-bred Kaka may have foraging deficiencies, supplementary food does need to be provided after release, but it should not be continued to such an extent that it inhibits the Kaka from learning the necessary skills to forage naturally.

5.0 INTRODUCTION

The aim of this chapter is based on a quote from Southgate (1994):

> "A reintroduction programme fails when no useful information is produced to assist in the long-term conservation of a species. This situation may arise either when a released population declines or prospers".

This chapter therefore summarises my findings, as well as suggesting possible directions of future research and management.

5.1 RESEARCH FINDINGS

5.1.1 Chapter 2: Post-release survival and movements

Survival was high for both captive-bred and wild-caught juvenile Kaka after release. This suggests that wild-caught, and perhaps more importantly captive-bred juvenile Kaka, can survive on the mainland in the presence of predators, when assisted by post-release supplementary feeding and low-level predator control.

There was high site-fidelity after release, with all the Kaka moving a limited distance from the release site and generally staying within Mount Bruce Reserve. This suggests that translocated wild-caught juvenile Kaka will stay near the release area after release when released using a delayed-release method. A soft/delayed release method is more demanding in terms of time and resources than simply releasing animals immediately on arrival at the release site. However, the ability of Kaka to fly great distances, and the actions of Taepiro after release in my study, indicate that Kaka require some time in captivity at the release site prior to release.

5.1.2 Chapter 3: Post-release Supplementary Feeding

Supplementary feeding was probably valuable in the period after release to ease the birds' transition to a new environment, and may have played a part in keeping the birds close to the release site. However, the fact that two of the wild-caught Kaka did not use the feedstations at all during the six months they were monitored suggests that Kaka can survive in Mount Bruce Reserve without food supplementation. Also, usage of supplementary food does not necessarily imply that it is needed. If food is supplied continuously, and used by birds, we cannot tell whether it is needed or not.

While the National Wildlife Centre at Mount Bruce Reserve has the means to provide supplementary food to the released Kaka indefinitely, future reintroductions of Kaka will probably be to areas where there are no resources available for prolonged supplementary feeding. Therefore, a necessary component of the Mount Bruce release project in the future should be to see whether the captive-bred Kaka can revert totally to a wild situation, which includes no dependence on people for food. This could be determined by a controlled experiment such as I described in Chapter 3, with on/off provision of supplementary food and monitoring of the Kaka to determine whether they lose condition during times of non-provision. Such an experiment could also determine whether the natural resources of Mount Bruce Reserve are alone sufficient to sustain a population of Kaka on a long-term basis, and the degree to which additional assistance is needed.

5.1.3 Chapter 4: Post-release Behaviour

Both the captive-bred and wild-caught juvenile Kaka adapted well to the environment of Mount Bruce Reserve. All the Kaka showed they were capable of identifying and searching for natural foods. While the captive-bred Kaka exhibited certain behaviours that may seem risky (spending time on the ground) and others that seemingly put them at a disadvantage (lower intake rates), these behaviours were not excessive enough to affect the survival of these Kaka, and thus their suitability for release into the wild.

The high degree of sociality after release enabled the Kaka to learn certain skills from each other. Sociality also plays a major role in whether individuals in future releases assimilate into the established group of Kaka at Mount Bruce Reserve. This has already been investigated at Mount Bruce with the release of five parent-reared captive-bred juvenile Kaka in June 1997. The results of this release are documented more fully elsewhere. Suffice to say that these five Kaka also survived the six months they were monitored after release, and showed behaviour comparable to the wild-caught and hand-reared Kaka released in 1996.

5.2 THE FUTURE

Reintroducing Kaka to Mount Bruce Reserve is only the first step towards establishing a viable Kaka population at Mount Bruce. The Kaka must survive to breeding age, and then breed successfully to ensure long-term persistence of the population. Management of the Kaka population at Mount Bruce Reserve should now focus on achieving this objective.

Population viability can be increased by increasing productivity and/or by decreasing mortality (Beissinger & Bucher 1992). This involves determining what factors limit population growth and then reversing these factors through intensive management (Beissinger & Bucher 1992, Beissinger 1997, Stoleson & Beissinger 1997). Kaka, as with most parrot species, have a breeding strategy which commonly involves long-lasting pair bonds, delayed maturity, hole-nesting, small clutches, long incubation and nestling periods, high parental investment and fledging of few offspring (Smith & Saunders 1986, Gnam & Rockwell 1991). In addition there may be a high proportion of non-breeders within a population, and breeding pairs may not attempt to breed every year (Stoleson & Beissinger 1997). Kaka also have to cope with high levels of predation on nesting females, eggs, nestlings and young fledglings (Moorhouse 1990, Beggs & Wilson 1991, Wilson *et al.* 1998).

Potential ways to increase the productivity of parrot populations include maximizing the number or proportion of adults breeding (eg. number of active nests), the percentage of nests fledging young (nesting success) and the number of young fledged per nest (fledging success) (Beissinger & Bucher 1992, Stoleson & Beissinger 1997). A management option used to increase the number of breeders, nesting success and fledging success is to provide nest-boxes (Toland & Elder 1987, Mawson & Long 1994, Newton 1994). Predator proofing natural nest sites also aids nesting success, while supplementary food can increase the number of breeders and fledging success (Beissinger & Bucher 1992).

Birds often accept well-designed artificial nest sites in preference to inferior natural sites (Toland & Elder 1987, Cade & Temple 1994, Newton 1994). Also, nesting and fledging success are often higher in nest-boxes than in natural cavities (Moller 1989). Since 1975-76 all breeding Puerto Rican Parrot pairs have used artificial or 'improved' natural sites that incorporate a number of weather-proofing and anti-predator features (Wiley 1985, Cade & Temple 1994). Reproductive output improved from 11-26% successful nests each year before 1975, to 70% after improvements were made to nest sites and/or artificial nest sites were used. In the case of the ground-nesting Bahama Parrot (*Amazona leucocephala bahamensis*) on Abaco Island, which suffers from high levels of predation by feral cats, alterations to nest cavities and a feral cat control programme have been required to increase productivity (Gnam & Rockwell 1991). In 1989 the only Bahama Parrot nests that fledged young were those surrounded by protective fencing to prevent predation by feral cats (Gnam 1990, Gnam & Rockwell 1991). Wilson *et al.* (1998) observed 20 breeding attempts by South Island Kaka during the period from 1985/86 to 1995/96, but only two attempts were successful with four chicks surviving to independence. Two of these four chicks were from a nest which had been protected from climbing predators.

Because predation of nesting adult female Kaka by stoats is a major factor in the decline of Kaka populations (Wilson *et al.* 1998), it is clear that management of nesting Kaka and/or control of predators at Mount Bruce Reserve should be a prime concern as the Kaka reach breeding age. There are already plans underway to erect predator-proof nest-boxes in the Reserve in the coming year, in anticipation of future breeding attempts. More intensive predator control than what is currently occurring may also be needed.

It is also important to find out to what extent the natural resources of Mount Bruce Reserve can support a Kaka population on a long-term basis, and the degree of human assistance that is required. While it is important to find out whether released Kaka in a non-breeding capacity can survive without assistance, breeding Kaka need more intensive management, which may include supplementary feeding, to boost productivity. Wilson *et al.* (1991) investigated whether supplementary feeding of South Island Kaka improved breeding success. While this experiment failed to determine whether natural food shortage limited the number of Kaka breeding and nesting success, it did suggest that food supplementation helped assist males to better provision females, thereby improving fledging success (Wilson *et al.* 1998).

Future breeding success of the released Kaka will also depend on their behaviour, especially since all the female Kaka currently present in the Reserve are hand-reared birds. Myers *et al.* (1988) investigated the reproductive success of hand-reared versus parent-reared Cockatiels (*Nymphicus hollandicus*) in a captive situation. They found that hand-rearing of either male or female Cockatiels produced gender specific effects that greatly altered reproductive success. Hand-reared females were more likely to lay eggs on the ground rather than in nest-boxes, reducing hatching success. Pairs containing hand-reared males were also less likely to produce fertile eggs, inspect nest-boxes, or lay eggs in nest-boxes. Fledging occurred only in pairs containing parent-reared males. Myers *et al.* (1988) suggested that in cavity nesting birds, habitat imprinting is significant since as well as being a nest for eggs nest sites can also be a stimulus for reproductive activity. It is therefore important that monitoring is undertaken to assure that the released Kaka have a repertoire of adult sexual behaviours that includes the ability to identify cavities as potential nest-sites (Myers *et al.* 1988).

In my study I observed Burwood (hand-reared male) investigating hollows in trees after release. Setting up nest-boxes in the Reserve well before the Kaka reach sexual maturity will allow them time to investigate the nest-boxes as potential future nest sites. Releasing the Kaka as juveniles has also allowed time for socializing with Kaka in the wild, and for some of the possible behavioural deficiencies of hand-rearing to be reversed. Because Kaka breed successfully under the artificial conditions imposed by captivity there is of course no reason why captive-bred birds can not breed in the wild, where they are free to select their own mates and nesting sites (Low 1984).

In addition to monitoring future breeding activity, monitoring of the released Kaka in a general sense should also be ongoing, both to assess the success of previous actions and to detect any new problems. Observations of the Kaka population at Mount Bruce Reserve will also contribute to the management of Kaka in general.

A final issue is whether the initial population is now large enough, or whether further Kaka should be released. Theory states that the risk of extinction is greater for small populations (Ryan & Siegfried 1994) both for demographic and genetic reasons (Lande & Barrowclough 1987, Lande 1988, Shaffer 1981, 1987). The general trend in reintroductions is that populations are more likely to survive if more animals are released (Griffith *et al.* 1989, Veltman *et al.* 1996, Duncan 1997, Green 1997). Griffith *et al.* (1989) calculated that 80-120 animals need to be released, on average, to maximize the probability of the population surviving. However, in most cases the majority of animals released are immediately lost to mortality and dispersal. While only 14 Kaka have been released at Mount Bruce Reserve (nine in 1996 and five in 1997), 13 have survived and stayed near the release site, and this may be sufficient for an initial population. The population size needed for long-term persistence will depend on the biology of the species. For example, many New Zealand birds seem to have a naturally high level of inbreeding, hence are likely to be able to persist in small isolated populations (Craig 1991). Previous transfers of New Zealand species have involved as few as five to as many as 386 birds. There has been a 77% success rate in establishing self-sustaining populations, and transfer success has not been related to the number of individuals released. With appropriate management even populations with as little as 7-10 pairs can have at least medium-term viability (Craig 1991).

5.3 CONCLUSION

This project has shown that it is feasible to set up a population of juvenile Kaka at a mainland site. The techniques used in this project can also be applied to other situations such as where the aim is to augment an existing population or move individuals between populations. Juvenile Kaka reared in captivity can be released into the wild with a high probability that they will survive.

This project has been a success in that we now know translocation and reintroduction techniques for Kaka can be utilised in the future if they are needed. The real challenge for the future will be managing existing wild Kaka populations on the mainland so that such techniques are not needed at all.

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