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# The Impact of Predation on the Threatened Endemic Kereru (*Hemiphaga novaeseelandiae*) by Mammalian Predators on Banks Peninsula, New Zealand

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**ABSTRACT:** The kereru (New Zealand pigeon) is a threatened endemic species. Predation of eggs, chicks, and adults at nests by mammalian predators is considered to be a major potential threat. The impact of mammalian predators on kereru populations was studied on three remnant native bush areas on Banks Peninsula, New Zealand, from February 2004 to March 2005. In this study, 15 kereru were fitted with radio-transmitters and intensely monitored for survival. Three radio-tagged kereru were lost at the beginning of this study and their transmitters were redeployed, so a total of 18 radio-tagged kereru were monitored for predator-induced mortality. Five adult kereru died, 3 as a result of predation. A cat was recorded on video preying on one adult. It is hypothesised that cats were responsible for preying on other kereru during this study. Rat and possum predation limited nesting success; however, this could have been offset by replacement nesting after nest failures. Cats preyed on chicks and adult kereru, which impacted the breeding viability of the adult population. Kereru may be able to withstand some nest predation pressure if the pair is able to re-nest in the same season. However, the ability of kereru to re-nest is reliant on them having an adequate food source, so this may not be possible in poor seasons. These assertions require population modelling to determine their relative importance. Nesting success would benefit from rat and possum control during good breeding seasons. Adult survival would benefit from the control of predators such as cats and stoats. However, as kereru have integrated into urban habitat, managers must consult with the community before conducting predator control.

**KEY WORDS:** adult mortality, community involvement, domestic cat, *Felis catus*, *Hemiphaga novaeseelandiae*, kereru, mammalian predators, nest success, survival index

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## INTRODUCTION

The kereru or New Zealand pigeon (*Hemiphaga novaeseelandiae*) is of a genus endemic to New Zealand. Kereru play an important role in the restoration of native forests, as they are the only surviving native bird capable of distributing the seeds (>12 mm) of large-fruited native trees (Clout and Hay 1989). Banks Peninsula, on the eastern coast of the South Island of New Zealand, was once known for its abundance of kereru (Evison 1993). Today, however, populations exist in fragmented remnants of native forest and regenerating habitat, dispersed amongst a mosaic of exotic pasture and scrubland, in relatively low numbers. Deforestation, habitat degradation, illegal hunting, and predation by introduced mammalian predators have all adversely impacted on kereru populations (Mander *et al.* 1998). Kereru decline today is largely attributed to the predation of eggs, chicks, and adult kereru by introduced mammalian predators including possums (*Trichosurus vulpecula*), rats (*Rattus* spp.), stoats (*Mustela erminea*) and cats (*Felis catus*) (Clout *et al.* 1995a,b; James 1995; Powlesland *et al.* 2003). The status of kereru is considered as endangered and listed as in gradual decline. Little is known of the status of kereru populations on Banks Peninsula other than that their numbers have dramatically decreased since the removal of 99% of the original forest cover, but now that native forest is regenerating, it is hypothesised that forest cover may now better support kereru (Wilson 1998).

This project was undertaken under the auspices of the Kaupapa Kereru Programme, an initiative to enhance kereru populations on Banks Peninsula. Kaupapa Kereru comprises representatives of Ngai Tahu Runanga, the Department of Conservation, Manaaki Whenua/Landcare Research, Banks Peninsula Conservation Trust, and Lincoln University. Kaupapa Kereru was established with the vision of increasing the numbers and range of Kereru on Te Pataka a Rakaihautu/Banks Peninsula through a two-pronged approach: firstly, by working with the local community to raise awareness and appreciation for kereru, including their key role in the restoration of indigenous forest; and secondly, through research on the ecology of local kereru populations including habitat, seasonal movements, foods, and the impacts of predators. This study focused on the latter, the impacts of predators.

The loss of an individual nest due to predation for kereru can be offset by the fact that they can re-nest soon after failure has occurred. However, the loss of mature breeding adults from a population is likely to have a greater impact than the loss of nests (James 1995). Adult kereru are vulnerable to predation especially when feeding on the ground (Mander *et al.* 1998) or within close proximity to the ground. Clout *et al.* (1995a) radio tagged a total of 102 kereru, of which a stoat killed 6 and a cat killed 1. Powlesland *et al.* (2003) also radio tagged adult kereru, which suffered high mortality resulting in a mean life expectancy of just 1.5 years. Of 74 tagged kereru, 41 died, 8 from unknown causes, 26 were preyed

upon (most probably by mammalian predators), 4 were taken by poachers, 1 died of disease or poor condition, and 2 were found being eaten by New Zealand falcons (*Falco novaeseelandiae*). The remains of 26 non-tagged kereru were found during Powlesland's study, of which 7 could be attributed to mammalian predation. Adult birds were especially vulnerable to predation from cats and stoats when drinking from puddles and streams on the ground (Powlesland *et al.* 2003). The loss of adult birds may have a major effect on kereru populations, because eggs can be replaced, but if an adult is killed, then the other parent may starve to death trying to raise their young, which may also starve (Clout *et al.* 1995b).

The removal of predators that prey on adult kereru would enhance kereru populations, but these predator species may differ from those that prey on nests. Therefore, the aim of this study was to identify predator species preying on adult kereru and to estimate the proportion of the total adult population that is lost to predation. Based on these results, a finite survival rate was developed for the population of radio-tagged kereru.

## METHODS

Fifteen adult kereru were fitted with radio-transmitters to monitor their movements and feeding habits and to find nest locations around Lyttelton Harbour. Three died early on in this study, so their transmitters were redeployed, making the total number of birds monitored for mortality 18. Each bird was distinguished by its transmitter frequency code (e.g., Tx 12). Observations of each kereru were made during 4- to 5-day field trips each fortnight from February 2004 to March 2005 (Schotborgh 2005). An attempt was made to locate each bird at least once a day during these field trips. Where the general location of a tagged kereru was obvious but could not be defined, its location was estimated through triangulation. Survival of the 18 radio-tagged kereru was monitored and the proportion that died from predation events was used to estimate the impact of predators on the mortality of adult kereru. Non-radio-tagged kereru found to have been preyed on were also inspected for signs of predation.

### Analysis of Remains

The remains of birds believed to have been preyed on were recorded at each such event. Remains were weighed, and this was compared with the birds' weight at the time of capture to determine how much of the kereru had been eaten. Body parts taken, i.e., head, feathers, and feet, and what was left of the kereru remains were recorded. How cleanly the meat had been eaten off the bones was also recorded. If faeces were found near the predation site, then they were taken to help identify the predator.

Bite marks were analysed by measuring the width between canines (Lyver 2000). Inter-canine distances were categorised as 'definite stoat' (<7.8 mm), possible stoat (7.8 to 9.5 mm), and outside stoat inter-canine distances range (>9.5 mm). Within the latter, a definite cat range (>13.6 mm) was designated. For inter-canine distances between 9.5 and 13.6 mm, there is some overlap between juvenile cats and ferrets, so a predator cannot be identified solely on inter-canine distances within this range (Lyver 2000).

## Site Analysis

When a depredated kereru was found, key habitat factors at the site were recorded to determine what factors may encourage predation of adult kereru. Those factors were: 1) the type of plant the bird was presumed to have been in prior to being preyed on, 2) the height of the plant (used to determine the proximity of the bird to the ground), 3) the amount of cover the bird had while it was on the plant, and 4) what the bird was doing in that plant prior to being preyed on (i.e., whether the plant was a known food source, roosting perch, or nesting site). The latter was discerned by observations of other kereru in the same plant species.

## RESULTS

### Adult Survival

A total of 5 radio-tagged kereru died from February 2004 to March 2005 (Figure 1). The first death occurred within the first week after the radio tags were fitted. It is possible that this kereru may have been suffering from post-capture shock associated with prolonged handling. Within the first few weeks of radio tracking, we found 2 radio-tagged kereru that had been preyed on by an unknown predator. Because these deaths occurred during the preliminary stages of this study, 3 more adult kereru were captured and radio-transmitters redeployed. A nesting radio-tagged adult kereru and its chick were preyed on while on the nest. The predator was conclusively identified as a cat by means of a 24-hr infrared video camera positioned adjacent to the nest. One kereru was presumed to have died.

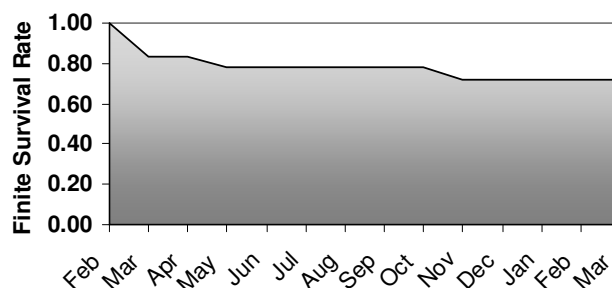


Figure 1. Finite survival rate of radio-tagged kereru from February 2004 to March 2005.

### Causes of Mortality

One kereru was found dead within the first week of this study (Table 1). It did not show any signs of predation. An autopsy was conducted to determine cause of death. This adult kereru was found to have a broken shoulder bone, possibly as a result of collision with an object whilst in flight. With an injury like this, the bird would not be able to fly long distances to find food or to evade predators.

Two radio-tagged adult kereru were preyed on either by a cat or a stoat in a poroporo (*Solanum laciniatum*) patch. Many kereru had congregated to this site and fed on the poroporo berries during February and March 2004. At this site, another 6 non-radio-tagged kereru were found to have been preyed on.

**Table 1. Mortality of radio-tagged kereru and causes of death from February 2004 to March 2005.**

<b>Total weeks of study</b>		56
<b>Number of radio tagged kereru</b>		18
<b>Total deaths</b>		5
<b>Causes of death</b>	<b>Transmitter code</b>	<b>n</b>
Cat predation	Tx 22	1 (plus chick)
Stoat / cat predation	Tx 16, Tx 28	2
Broken collar bone	Tx 26	1
Unknown	Tx 12	1

A radio-tagged adult kereru was preyed on while brooding a chick in a nest. This event was caught on camera; however, this occurred at night and happened so fast that the predator could not be identified. The 10-day-old chick was preyed on the next day, which was also caught on video, and clearly shows a cat entering the nest and taking the chick. The nest was 2.5 m high in a *Coprosma rotundifolia* tree.

A fifth radio-tagged bird was assumed to have died, as it stayed in the same place for the majority of the year and never left. This could not be verified, as it was located in a remote area of Mount Herbert Reserve that could not be accessed. Its location was determined by triangulation.

### Analysis of Remains

Three radio-tagged kereru and 6 non-tagged kereru were found to have been preyed on during this study. In each case, a significant amount of the carcass had been consumed (81-89%). Few of the kereru parts were left at predation sites; predominantly the primary, secondary, and tail feathers remained. The feet were seldom found, and the head of the bird was never found. Few bones remained, primarily the sternum or leg bones, if bones were present. Bones retaining bite marks were used to identify the predator by measuring inter-canine distances. In some cases the bones were crushed, making identification impossible. Inter-canine distances ranged from 12-16 mm, which is highly likely to be that of an adult cat (Lyver 2000).

### Site Analysis

The 3 radio-tagged kereru that were preyed on were found below low-lying shrubs ( $\leq 2.5$  m). Tx 22 was nesting in a *Coprosma rotundifolia* shrub, under which it was found. Tx 28 and Tx 16 were presumably feeding on the ripe berries of poroporo. The remains of another 5 untagged kereru were also found in this patch of poroporo around the same time as the depredated radio-tagged kereru were found.

## DISCUSSION

### Adult Mortality

There are a number of possible causes of death for the kereru with a broken wing that led to its eventual death. It is possible that this injury could have been caused during the capturing and attaching of the radio transmitter to this bird. In the capturing and handling of kereru that were fitted with radio-transmitters, all precautions were taken and adhered to under the Department of Conserva-

tion guidelines (Schotborgh 2005). All handling was conducted by professionals with years of experience in handling wildlife. So, every effort was made to limit stress and injury to the kereru whilst being handled, and the bird was observed and found to be in reasonable health after its release, some distance from the capture site.

It is also possible that this bird collided with a moving vehicle or flew into a window, as this bird was found in close proximity to urban dwellings. A high proportion of adult kereru have been known to die or become seriously injured after colliding with motor vehicles. Collision with motor vehicles after feeding on roadside foliage is considered a major cause of death for kereru in Akaroa Harbour, Banks Peninsula. For this reason, Mander *et al.* (1998) recommend that food species should not be planted adjacent to roads, so kereru are not attracted to roadsides.

The majority of kereru mortalities (3) were apparently the result of cat predation. The fact that other non-tagged kereru that had been preyed on were found at the same time and same site as the radio-tagged kereru in this study suggests that the predations generally were not the result of being fitted with radio-transmitter backpacks. Rather, the predation of kereru was more likely to be related to the low shrubs the birds fed in, and their proximity to the ground.

### Site Analysis

As 2 of the radio-tagged kereru and 5 non-tagged kereru were preyed on while feeding on poroporo shrubs, it is perceived that kereru may be vulnerable to predation while feeding on low shrubs. In a study by Clout *et al.* (1995a) of kereru survival at Pelorus Sound, 5 kereru were preyed on at the same site, in a large patch of broom (*Cytisus scoparius*) bushes on the forest edge. Kereru congregated at this site in small flocks to feed on foliage and flowers. Remains bore characteristic signs of stoat feeding, including stoat canine marks on the sternum.

Keru will show signs of stress when feeding on plants low to the ground. This is exhibited by short feeding bouts and wary behaviour. Stress during feeding uses a lot of energy, reducing the nutrition gained. Predator-induced stress may have implications for kereru breeding success and may also be a factor contributing to adult starvation. Kereru have been observed feeding on poroporo for short bouts and then flying to roost up a tree. During feeding, they exhibit wary behaviour (Schotborgh 2005).

Adult kereru are also vulnerable, like many native avian species, during the incubation period and when brooding chicks. This also impacts on nesting success, because with the loss of one parent, the other parent cannot raise the chick or egg on its own. At Pelorus Bridge, 2 nests failed as an indirect result of the loss of one of the parent birds (Clout *et al.* 1995a).

### Analysis and Interpretation of Remains

One issue with the interpretation of remains after a predation event had occurred was the ability to discern whether signs used to identify predators were from the predator of the adult kereru or were a subsequent animal

that scavenged on the remains. There were a lot of possum faeces around predation sites, so it is presumed that possums may have been scavenging kereru remains. They were probably attracted to the area for the same reason that the kereru were there, to feed on the poroporo berries. For this reason, the identification of the primary predator could not be conclusively discerned from scavengers.

For most predators, the killing strike is to the head or the back of the neck. Therefore, to distinguish between predators and scavengers, Lyver (2000) suggests examining bite marks on the skull, as these are usually the killing bites and should be used to determine the predator. However, in this study no skulls of preyed birds were found at any of the predation events. Therefore, analysis of bite marks on other bones can only be used to provide circumstantial evidence of which predator was responsible, because we cannot distinguish between predators and scavengers.

### Predators of Adult Kereru

Cats were identified as a major predator of adult kereru in this study. Video evidence showed that cats were possibly the predator of a radio-tagged adult bird and conclusively a predator of a kereru chick (Prendergast 2006). It was not determined, however, whether the cat was feral or domestic. The distances of the inter-canine bite marks (12-16 mm) found on the bones of the kereru carcasses were consistent with that of cats (>13 mm).

Australasian harriers are natural predators of kereru and were present at the sites where adult kereru were preyed on. When kereru spotted harriers hovering above them, they instinctively took to the air and circled. Stoats were present at Orton Bradley during this study. Stoats have been identified in other studies as major predators of adult kereru in shrubs (Clout *et al.* 1995a). Because of the low proximity to the ground, it is possible that ferrets (*Mustela furo*) could have been responsible for the predations that occurred in low-lying shrubs.

### CONCLUSIONS

Because we are dealing with a population of kereru in and around human habitation, we as managers have to consider the human element. Local residential properties with native and exotic plantings contribute to kereru diet and increase habitat. With human habitation, though, also comes an increase of predators such as cats and dogs. Therefore, predator control may not be applicable, as pets may be impacted. Agricultural practices may be beneficial, as predators such as possums and cats are controlled to protect livestock from diseases passed on by these predators. For management to be successful, there are many considerations that need to be dealt with, which can only be achieved through proper consultation. The success of Kaupapa Kereru is that the local community is involved and is supportive of the programme goals. Research to enhance kereru populations is disseminated to the local community through pamphlets, calendars, local publications, and public talks.

This study identified cats as a major predator of adult kereru. Kereru were occasionally preyed on while feed-

ing on the fruit of low-lying (<3 m) poroporo shrubs. Poroporo produces fruit 11 months of the year; however, it has a peak fruiting during the hottest time of the year (January-February). Control of predators, therefore, would be best focused during peak fruiting of poroporo when adult kereru are vulnerable to predation. It was not determined whether the cats were feral or domestic. Cat owners in areas adjacent to key habitat sites need to be educated on the threat that their pets pose to kereru populations. It is recommended that cat owners keep their cats inside during the night (from dusk until dawn), as this is the time when cats are most suited for hunting (Fitzgerald 1998, Saunders and Maloney 2001).

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