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CONTENTS

A TRIAL TO DETERMINE WHETHER KAKA CONSUME CARROT BAITS, KAPITI ISLAND, MAY 1993

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ABSTRACT

A bait acceptance trial was undertaken to determine whether kaka (*Nestor meridionalis*) would consume toxic carrot baits applied to forest areas during possum control operations. Carrot baits treated with a fluorescent biotracer were broadcast over c. 170 ha of forest on Kapiti Island on 21 May 1993. Over the following 11 days kaka were caught and examined for traces of the biotracer on 25 occasions. Only one kaka, a juvenile, was found with traces of the biotracer indicating it had consumed carrot baits. Beak marks attributed to kaka were found on three carrot baits. No traces of biotracer were observed in kaka droppings found near supplementary feeding stations. Biotracer occurred in many weka and rat droppings and one pigeon and one robin dropping.

The carrot baits contained a high proportion (72% by frequency or 31% by weight) of fragments less than 5 mm in length. Harrison (1978) reported that 1080 operations using carrot baits with small fragments killed many more birds than operations without small fragments.

1. INTRODUCTION

Environment Waikato (the Waikato regional council) proposed to control possum numbers in the Ngaroma Block, northern Pureora Forest, central North Island, during June 1993, by aerial broadcast of carrot baits surface coated with 1080 poison. In response to last minute concern over the possible impact of the proposed operations on kaka (*Nestor meridionalis*), Science and Research Division conducted non-toxic bait acceptance trials for kaka on Kapiti Island, off the south west coast of the North Island.

The biotracer commonly used for non-toxic bait acceptance trials is the bright red fluorescent dye, rhodamine-B. Unfortunately, because many New Zealand birds, including kaka, are attracted to bright red dyed baits (Udy & Pracey, 1981), rhodamine-B is not a suitable biotracer for trials to assess bait acceptance by birds. Before the nontoxic bait trials could be undertaken it was necessary to find a suitable biotracer which did not affect the appearance or palatability of green dyed carrot baits but could be detected on kaka at extremely low concentrations.

2. MATERIALS AND METHODS

2.1 Materials and Suppliers

Wanganui No. 7 Pellets -Animal Control Products, Wanganui.
Pyranine 120%, Fluorescein, Blankophor-P liquid, & Special Green V200A Dye-Bayer New Zealand Ltd., PO Box 38-405, Petone.
4 watt or 6 watt UV torches -Watson Victor Ltd., PO Box 1180, Wellington.
4 watt UV torches -Pest Management Services Ltd. 28 Bancroft Tce., Newlands, Wellington.

2.2 Selecting a Biotracer

Consultation with dye chemistry experts and consideration of manufacturer's product information led to selection of three commercially available dyes likely to be suitable: Fluorescein, Blankophor-P liquid, and Pyranine 120%. All three dyes fluoresce when irradiated with ultra -violet (UV) light and can thereby be detected at low concentrations. Fluorescein is a bright yellow dye and fluoresces yellow; Blankophor is colourless but fluoresces blue/white; and Pyranine is a pale yellow green and fluoresces green.

Screening trials were undertaken on each of these three dyes to determine which was the most suitable. These trials examined the dye's persistence on baits exposed to sunlight and rainfall, its affect on the appearance and palatability of carrot baits, and its persistence and ease of detection on animals following consumption.

2.3 Pyranine

The result of the screening trials described in the results section led us to choose Pyranine 120% as the biotracer. This is an odourless, pale yellow-green, non-toxic, biologically inert, dye. Table 1 provides key information on safety and ecological effects from the Safety Data Sheet supplied by the supplier, Bayer NZ Ltd. LD_{50} is the median lethal dose, a statistical estimate of the dose in grams of toxin per kilogram of body weight which will kill 50% of a large population. LC_0 is the concentration of toxin in water at which no mortality is observed in a fish population.

Table 1 Characteristics of Pyranine 120%: from Safety Data Sheet supplied by Bayer NZ Ltd.

Acute oral toxicity (LD_{50}):	above 5 g/kg
Fish toxicity: LC_0:	above 0.1 g/l
Inhibition of waste water bacteria activity:	None at 1 g/l

Although Pyranine 120% is not strongly coloured, when irradiated with UV light it fluoresces strongly in the green region of the spectrum and can be detected at concentrations as low as 1 part in 10^{10} (Bayer Technical Product Information/Characteristic Data).

Samples being inspected for Pyranine were irradiated with UV light from 4 watt or 6 watt UV torches. The performance of the 4 watt torches was improved by inserting aluminium foil as a reflector around back of the emitter tube.

Because the fluorescence is too weak to be detected easily in daylight it was necessary to reduce visible light levels either by working at night, or using dark cloth capes or plastic cylinders as covers. Pyranine fluoresces most strongly in alkaline solutions, therefore soap-water or baking-soda can be added to faecal samples to enhance fluorescence.

2.4 Bait Preparation and Application

The trial was designed to simulate the proposed Ngaroma drop as closely as possible. Carrot baits were prepared in Te Kuiti on May 20 in the standard manner described in the draft DOC Pesticide Manual. They were coated with Special Green V200A dye (0.02% wt/wt), vegetable oil (0.1% vol/wt), cinnamon oil (0.1% vol/wt) and Pyranine (0.3% wt/wt). This concentration of Pyranine, which is the highest achievable using standard bait preparation procedures, was chosen because of uncertainties about the performance of Pyranine as a biotracer. It was necessary to warm water to 25-30°C to achieve the required concentration of Pyranine solution for coating the baits.

Baits were transported to Paraparaumu overnight by road and then broadcast on the morning of Friday 21 May from a rotary spreader beneath a Bell Jet Ranger Helicopter (pilot Charlie Anderson of Wanganui Aeroworks). A Geographical Positioning System (GPS) was not used during the drop. A total of 1680 kg of bait was broadcast over *c.* 170 ha of forest, the drop area encompassed the lower two thirds of the Te Rere and Kahikatea catchments starting 100 m above Rangatira Flats (Fig. 1). The target application rate for baits was 10 kg/ha. Unfortunately, during this trial we broadcast the baits evenly throughout the drop zone, whereas in the Ngaroma poison operation baits were broadcast in swathes 20-70 m apart. Although these swathes were distributed throughout the entire drop zone, they only covered about 30% of the area.

2.5 Post-application Monitoring

1. The quality and size distribution of baits was determined for a representative sample of baits taken from a single 25 kg sack of the carrot baits. Ideally samples should have been taken from a number of randomly sampled sacks. Unfortunately this was overlooked, but there were no differences apparent between the contents of sacks as they were fed into the hopper of the rotary spreader.

2. Eight 100 m^2 plots were marked out in representative forest types spread across the drop zone. The distribution of baits in each of these plots was mapped immediately after the drop and at intervals thereafter.

3. As researchers moved around in the drop zone they routinely inspected broadcast baits for feeding sign.

4. A time-lapse video camera was set up within the drop zone to monitor the fate of a cluster of 8 carrot baits placed on the ground in a 2 m^2 area.

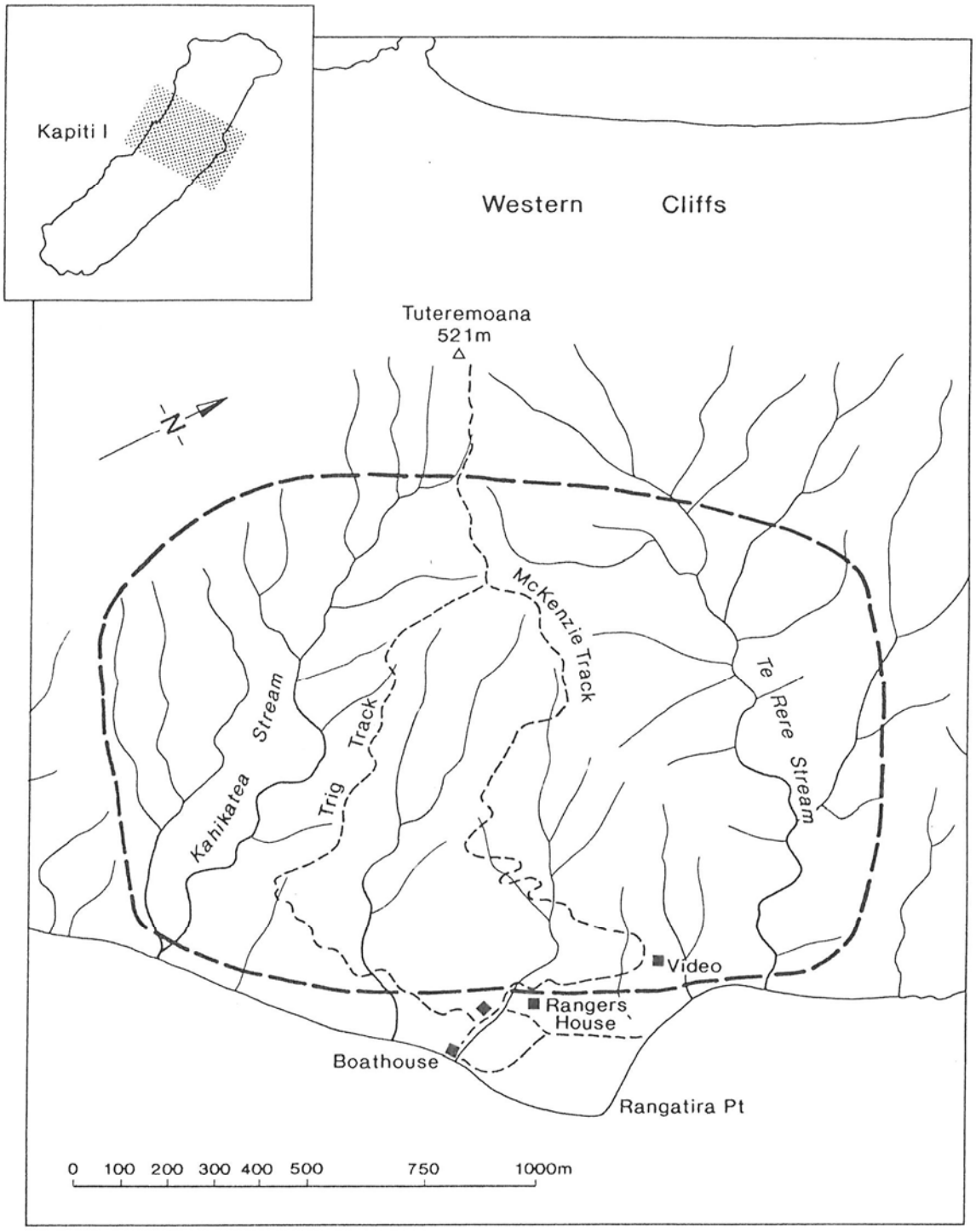

Figure 1 Te Rere and Kahikatea catchments, Kapiti Island; showing the approximate boundary of the drop zone.

5. As many kaka as possible were caught either in the drop zone or at the feeders around the ranger's house 50 m from the western edge of the drop zone (Fig. 1). Kaka that gather at the feeders normally forage over a wide area, including the drop zone (pers. com. R. Moorhouse). Each kaka was inspected for traces of Pyranine. Sex and age class were determined using a combination of criteria (weight, culmen dimensions and plumage appearance) after R. Moorhouse (pers. com.). Any unbanded kaka caught were banded with a numbered stainless steel band on one leg and two wrap around coloured Darvic bands on the other leg.

6. Kaka droppings around two feeding stations near the ranger's house were regularly inspected for Pyranine. Because of the large number of droppings and their unformed nature no attempt was made to identify individual droppings or to count the number examined.

7. Droppings of other species were routinely inspected for Pyranine. The total number of droppings examined was not recorded.

2.6 Contamination

Because Pyranine is persistent and can be detected in minute amounts there is a risk that researchers may contaminate study animals or samples with Pyranine. Most researchers (6 out of 8) did not handle baits during the drop. Those who did handle baits during the drop used protective clothing which was then thoroughly washed or discarded.

3. RESULTS

3.1 Selecting a Biotracer

Exposure to full sunlight for four days had no discernible effect on the fluorescence of carrot baits coated with Special Green V200A dye (0.02% wt/wt) and either Fluorescein, Pyranine or Blankophor at 0.1% (wt/wt). Solutions of Fluorescein and Pyranine both faded over a period of several weeks exposure to bright sunlight, although Pyranine was slightly more persistent. A solution of Blankaphor was not tested.

When carrot baits coated with Special Green V200A dye (0.02% wt/wt) and either Fluorescein, Pyranine or Blankophor at 0.1% (wt/wt), were washed in tap water, the V200 dye leached out and the fluorescent dyes remained.

Fluorescein was eliminated as unsuitable because its bright yellow colour was not completely suppressed by the Special Green V200A dye used on standard 1080 carrot or pellet baits, and because when the V200A dye leached from the baits the remaining Fluorescein turned the baits bright yellow. In contrast Pyranine's pale yellow-green colour was easily masked by the Special Green V200A dye and when the V200A dye leached out of the baits they remained a pale green similar to their original colour.

After 24 days exposure to 237 mm of rainfall detectable dye residue remained on Wanganui No. 7 Pellets (a grain based pellet) coated with either Pyranine 120% or Fluorescein at 0.1% (wt/wt).

Fluorescence was detectable in the faeces and urine of laboratory mice 48 hours after they were fed Wanganui No. 7 Pellets coated with any of the three dyes at 0.1% (wt/wt).

Trials were undertaken on captive kaka at Wellington Zoo. In one cage two kaka were fed a small number of carrot baits coated with Pyranine at 0.1% (wt/wt) and in a second cage two kaka were fed carrot baits coated with Blankaphor 0.1% (vol/wt). Carrot was a normal component of the diet of all four birds. There was no indication of any aversion to the dye treated carrot baits. Twenty four hours after consumption of the treated carrot baits fluorescence was detectable le on the upper palate and feet, and in droppings in both cages. Fluorescence from Pyranine was still detectable on the upper palate after 52 hours.

It was decided that Blankophor was unsuitable to use as a biotracer because its blue/white fluorescence was not easy to distinguish from the reflection of light from the DV torches off white surfaces.

When applied to carrots at the concentrations used in the Kapiti Island trial (0.3% wt/wt) Pyranine had no detectable taste or odour for humans. Fluorescence was apparent on human finger nails 17 days after handling Pyranine treated baits.

3.2 Bait Broadcast

Weather conditions during the bait drop were ideal, being both calm and dry. There were gaps in bait coverage which could have been avoided by using GPS during broadcast. These gaps should have no effect on the results of this study.

3.3 Post-application Monitoring

Monitoring was carried out for 11 days after the bait drop. By the end of this period more than 70% of the baits in eight 100 m^2 plots had disappeared and remaining baits were in advanced stages of decomposition. During the 11 day monitoring period there was only 13.0 mm of light rain, thus there was no problem with Pyranine leaching out of the baits.

3.3.1 Size distribution of baits

Table 2 is the size distribution of a sample of the carrot baits taken from a 25 kg sack kept aside for examination. The bait fragments were sorted into five size classes. More than 72% of the fragments (i.e., 2,383 of 3,293) were less than 5 mm long (i.e. less than *c.* 1.5 g weight).

3.3.2 Bait plots

A total of 309 baits of all size classes were found in the eight 100 m^2 plots. 177 of the baits were more than 5 mm and 132 were less than 5 mm. Using the sample data from the previous section (i.e. total weights and total numbers of baits both less than 5 mm, and greater than 5 mm) the bait application rate can be estimated as

$$\left(\frac{3.420\times177}{910} + \frac{1.515\times132}{2383}\right)\times\frac{10000}{800}$$

i.e., 9.36 kg/ha.

This is close to the target application rate of 10 kg/ha.

After the initial count baits less than 5 mm were not recorded as it was impossible to distinguish small baits from fragments left by animals feeding on larger baits.

177 baits, or 55% of the total number of baits, were larger than 5 mm. This includes 27 baits greater than 5 mm which fell from the canopy during the 10 days after the drop. These 27 baits constitute 15% of baits greater than 5 mm found in the plots. Only 28% of the baits larger than 5 mm remained in the plots 10 days after the drop (Table 3), and many of these remaining baits had been partly eaten by rats.

Table 2 The size distribution of baits
Sample size: N=3,293, Weight=4.93 kg

Size Class(mm)	<2.5	2.5-5	5-10	10-20	>20
Av. wgt (g)	0.24	1.09	2.36	5.22	10.0
n	1270	1113	502	386	22
% of total n	38.6	33.8	15.2	11.7	0.7
Total wgt (g)	305	1210	1185	2015	220
% of total wgt	6.2	24.5	24.0	40.9	4.5

Table 3 Disappearance of baits >5 mm on the plots

Days after the drop	0-1	2.5- 5	9-10
N. of baits >5mm in plot and canopy	177	80	50
% of original baits >5mm remaining	.	45	28

The absence of undyed surfaces on most baits immediately after the drop indicates that they did not fragment during broadcast.

Ten days after the drop the remaining baits on the plots still fluoresced strongly.

3.3.3 Feeding sign on baits
In the course of the monitoring programme many hundreds of the broadcast baits were examined for feeding sign. Three were found with distinctive beak marks characteristic of kaka, a 3-4 mm diameter crescent shaped beak mark and, or, a 4 mm wide slot. These three baits were found over a kilometre apart during the first few days after the

drop. Rat chews were common on baits; indeed towards the end of the monitoring most remaining baits had been partly eaten by rats *Rattus exulans* and *R. norvegicus*. Many baits were partly eaten by large insects (probably weta *Hemideina sp.).*

3.3.4 Video surveillance

A group of 8 baits on a 2 m^2 of forest floor was monitored for 6 days, starting 5 days after the drop, using a time lapse video system. No kaka were recorded visiting the baits. Weka *Gallirallus australis* and rats were both recorded eating and removing baits. Robins *Petroica australis* and a large insect (possibly a weta) were noted close to baits, but it was impossible to tell whether they had fed on them.

3.3.5 Captured kaka

During the 11 days after the drop (Table 4) 20 kaka were caught; 9 adults (4 males, 5 females), and 11 sub-adults (7 males, 4 females). Five were subsequently recaptured, giving a total of 25 captures. Most captures (18) were near the ranger's house (by hand, in cage traps or with a mist net set at the feeders); the remaining 7 captures were at mist nets in the forest within the drop zone.

Table 4 Number of kaka captured each day after the drop.

Days post-drop	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
No. kaka handled	0	3	3	4	3	0	4	3	2	3
Final capture	0	3	2	3	2	0	2	3	2	3

Each time a kaka was handled we inspected its beak, tongue, upper palate, cloaca, undersides of feet, and droppings for fluorescence. Only one kaka, a juvenile, showed traces of Pyranine. When this bird was first captured, five days after the drop, there was no sign of Pyranine. On recapture nine days after the drop the pale green fluorescence characteristic of Pyranine was visible in its droppings and on feathers around its cloaca.

Blood serum samples and cloacal swabs taken from 14 kaka for disease screening were inspected for fluorescence but none was observed.

3.3.6 Kaka droppings

A large number of kaka droppings found around the feeders at the ranger's house were inspected for Pyranine but no fluorescence was observed.

3.3.7 Droppings from other species

Fluorescence from Pyranine was observed in 10 of 87 weka droppings examined. The incidence of fluorescent droppings peaked at about 30% between 3 and 8 days after the drop. Fluorescence from Pyranine was also observed in many rat droppings, one kereru *Hemiphaga novaeseelandiae* dropping, one small passerine dropping (probably a robin), and one weta dropping. None of five kiwi *Apteryx oweni* droppings examined fluoresced.

3.3.8 Further evidence of bait consumption by other species
Two kereru, three tui *Prosthemedera novaeseelandiae,* and two bellbirds *Anthornis melanura* caught in mist nets were examined for traces of Pyranine but none was observed. Weka were seen feeding on baits on several occasions and one robin was seen flying off carrying a bait.

During intensive searches of the bait plots two rodent caches of carrot baits were found and large numbers of Collembola, or springtails (a small leaf litter insect *c.* 1 mm long) were found feeding on the baits. The alimentary tracts of the Collembola fluoresced strongly.

3.3.9 Natural food sources
During the trial kaka were observed feeding, in the forest of the drop zone, on abundant supplies of five-finger *Pseudopanax arboreus* fruit, passion-flower *Tetrapathaea tetrandra* fruit and kohekohe *Dysoxylum spectabile* flowers. These natural foods were in such abundance that kaka showed unusually little interest in the supplementary food (honey-water and cheese) provided at the ranger's house.

3.3.10 Natural fluorescence
In order to allay concern over confusion between fluorescence from Pyranine and naturally occurring compounds some time was spent in the forest at night searching for natural fluorescence using DV torches. A number of natural sources of pale green or pale blue fluorescence were found including small button fungi, patches of decayed wood, and diseased leaves of *Asplenium oblongifolium.* None of these sources seemed a likely food and all could be distinguished by colour from the fluorescence of Pyranine.

A bright yellow fluorescence was detected on the feet, beak and palate of two kaka; and on the feet of the two tui handled. The colour of the fluorescence was very different to that of Pyranine. Its source was not determined but it is presumed to be a naturally occurring compound.

4. DISCUSSION

4.1 Pyranine as a Biotracer

Pyranine proved to be a satisfactory biotracer for use in non-toxic bait trials. It does not significantly affect the appearance of baits but its fluorescence is easily detectable on them at least 11 days after broadcast. The results of this trial demonstrated that it can be detected in the droppings of several species following consumption of treated baits.

A lower application rate than the 0.3% (wt/wt) used in this study may provide satisfactory results.

The DOC staff at Te Kuiti who prepared the carrot baits for this trial found Pyranine easier to use than rhodamine B; it dissolved easily, and visible residues could be washed off hands and clothing.

Further work should be undertaken to develop methods to detect Pyranine at very low concentrations in small samples, to determine the length of time that Pyranine remains detectable after consumption, and to examine its potential to trace food-chains.

4.2 Size Distribution of Baits

The carrot baits contained a high proportion of small fragments; 72% of the bait fragments, or 31% by weight, were less than 5 mm long.

Harrison (1978) reported that 1080 poison operations using carrot baits with small fragments killed over 3 times as many small passerine birds as operations with no fragments smaller than 16 mm. There are several probable reasons for this difference: small passerines prefer small food particles; more baits are available when the fragments are small; small fragments are more likely to be caught in the canopy and be available to foraging birds; and because of the higher surface area to volume ratio the overall concentration of 1080 on surface-coated carrots (weight of 1080 to weight of carrot) is greater on small fragments than large ones.

DOC and regional councils have a policy of screening carrot baits to remove small fragments, both to reduce the incidence of non-target kills and to increase the effectiveness of control operation (possums are more likely to consume sub-lethal doses and acquire an aversion for 1080 when small fragments are used). The bait used for Kapiti Island trials was reportedly sieved to remove small fragments. If this is correct there must be a problem with the method being used. Carrot bait preparation methods for possum control operations should be reviewed and modified to exclude small fragments.

It is probable that the use of carrot bait with a larger proportion of small fragments than usual will have biased the results of this trial, but it is difficult to assess the nature of the bias. Our own observations that kaka prefer larger food items, and those of Spurr (1992) that captive kaka exhibited a preference for carrot baits larger than 2 g (i.e., >*c.* 5 mm) suggest that small fragments may not endanger kaka to the same extent as they endanger small passerines.

4.3 Behaviour of Supplementary-fed Kaka

Although kaka foraging behaviour is modified by supplementary feeding, our own observations of supplementary-fed kaka on Kapiti Island and Little Barrier indicate that supplementary-fed kaka are not predisposed to taking novel items such as carrot baits while foraging away from supplementary feeding sites. Our observations are supported by the observations of Ron Moorhouse (pers. com.) in the course of a 4 year study of kaka on Kapiti Island, and observations by P.Wilson (pers. com.) who has worked with supplementary-fed kaka in Nelson Lakes forests for several years.

4.4 Bait Consumption by Kaka

There was some evidence of kaka consuming carrot baits. Traces of biotracer were found on one juvenile kaka and beak marks attributed to kaka were found in three carrot baits. It should be noted that the baits with beak marks were not consumed; it may be

that during the first day after the drop cinnamon oil on the carrot baits had a repellent effect as reported by Udy & Pracey (1981) and Spurr (1992).

The indication of a low incidence of carrot bait consumption by kaka during this trial should be interpreted cautiously because:

- It is likely that the abundance of natural food sources available during this trial reduced the probability of kaka taking carrot baits. The abundance of natural food at Ngaroma during the control operation may be an important factor influencing the impact of the operation on kaka.

- Kaka forage predominately in forest canopy and are therefore most likely to take carrot baits caught in the canopy. The proportion of baits caught in the canopy will be influenced by canopy structure. During this trial at least 15% of the baits >5 mm were caught in the canopy for the first few days after the drop; the proportion of the smaller baits caught in the canopy was probably higher. Because the forest at Ngaroma generally has a thicker canopy with more epiphytes than the forest on Kapiti Island (pers. corn. Phil Bradfield, Ian Flux & Peter de Lange) a greater proportion of the baits is likely to be caught in the canopy and available to foraging kaka at Ngaroma.

Research by Wilson *et al.* (1991) on South Island kaka in Nelson Lakes forest indicates that juvenile and sub-adult kaka are neophilic (i.e. show an interest in novel items), whereas adults are neophobic (show an aversion to novel items). Thus it is not surprising that the only kaka showing traces of the biotracer was a juvenile. It is probable that young kaka are most at risk from 1080 poison drops.

4.5 Lethal Dose

McIlroy (1986) reported that the mean LD_{50} of 1080 for eight Australian parrot species was 3.97 mg k^{-1} with 0.00-9.28 95% confidence limits. Using McIlroy's mean LD_{50} for Australian parrots as the best available estimate of the LD_{50} for kaka, an average sized kaka on Kapiti Island (mean=430 g, n=19, s.d.=36.95 g, range 385-511 g) would consume an LD_{50} in 2.14 g of carrot bait with a 0.08% 1080 loading (i.e. a single moderate sized bait).

4.6 Calculating an Expected Kill Rate

A reliable estimate of the expected kill rate can not be calculated easily from the data collected in this trial. Calculation must take into account the time intervals between the drop and capture of each kaka (Table 4), the period after consumption during which Pyranine remains detectable, and the period after the drop during which 1080 treated baits would have remained toxic. Presently we have no data on the period during which Pyranine remains detectable. Calculating the expected kill rate as 1 in 20 (i.e. 5%) is likely to underestimate the expected kill rate as many of the kaka were exposed to the baits for periods much shorter than the period during which 1080 baits would have remained toxic.

4.7 Other Studies

Spurr (1990 and 1991) reviewed the results of four trials which monitored the effect on kaka populations of possum control operations using broadcast 1080 in two central

North Island forests, Whirinaki and Pureora. In each case five minute bird counts were carried out in treatment and non-treatment areas before and after control operations. In two of these operations (Whirinaki 1978 and Pureora 1985) the bait was carrot. In the other two operations (Pureora 1983 and 1984) the bait was grain based pellets.

Most researchers who have studied kaka (pers. comm. R. Moorhouse, C. O'Donnell, P. Wilson and the authors) believe that five minute counts are unreliable indicators of kaka's abundance because of the species' mobility, seasonal and diurnal fluctuations in their conspicuousness, and their rarity in most mainland forests.

Warren (1984) and Calder & Deuss (1985), in their accounts of the 1983 and 1984 trials at Pureora, indicate that because of the sample sizes and average count rates the minimum detectable changes in kaka numbers during these trials were 25% and 38% respectively.

In his discussion of the results of the four trials Spurr (1991) noted that there were significant changes in kaka numbers with time and stated:

> *"there was no evidence that the changes after poisoning were any different to changes before poisoning. For example, kaka numbers decreased in the Whirinaki* [carrot] *poison area after poisoning but increased after poisoning at Pureora in* 1984 [pellet]. *Without further information on kaka behaviour and movements it can only be concluded that poisoning was not responsible for these changes."*

We believe that, because of problems of interpreting five minute counts of kaka and the lack of sensitivity of the trials, Spurr's conclusion is not warranted. The results of the trials are inconclusive, though the 45% reduction in kaka counts in the area poisoned with carrot baits during the trial at Whirinaki in 1978 is a cause for concern.

4.8 Bait Consumption by Other Species

72% of baits >5 mm long on our plots disappeared in the ten days after the drop and were presumably eaten or removed to caches. There is evidence that large numbers were consumed by weka and rat. NZ pigeon and possibly robins may also consume small numbers of carrot baits. Observations of Collembola feeding on baits are significant as Collembola (along with other small invertebrates likely to feed on the baits) are the base of food chains which lead to an array of larger invertebrates and vertebrates. Whether such food chains provide a route for indirect poisoning will depend on the rate at which the toxin is metabolised.

5. CONCLUSION

The haste with which this trial was undertaken led to a number of deficiencies in its design and execution, but we believe that these deficiencies do not compromise the conclusion.

The results of this study, and the results reported by Spurr (1992), indicate that there is some risk of kaka consuming baits during 1080 operations using carrot bait. The level

of risk is likely to be influenced by the availability of alternative natural food sources. The risk may be greatest for young birds.

Until further information is available we recommend that a conservative approach be adopted: grain based pellets should be used for possum control operations wherever kaka are present in significant numbers.

Greater concentrations of cinnamon oil on carrot baits may reduce the probability of kaka consuming baits (Spurr 1992).

Neither the tracer methods used in this study nor five minute bird counts can provide conclusive evidence on the impact on kaka of aerially broadcast 1080 baits. If possum control operations are to proceed in the few mainland areas of the DOC estate where kaka remain in significant numbers, further work is required to establish in a conclusive manner whether kaka are killed during the operations. Monitoring large samples (>20) of radiotagged kaka throughout poison operations is the most effective method currently available to achieve this.

Further research should also be undertaken to develop a reliable and inexpensive method for routine monitoring of kaka numbers. The most promising method is the multiple observer census technique. In this technique a number of observers at vantage points in a block of forest simultaneously record the details and location of all kaka heard or seen. The records are collated to make a reasonable estimate of the number of kaka present in the area surveyed. Surveys should be designed to take advantage of flocking in the evenings and at clumped food resources, and calling from night roosts.

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