# Exposure of feral pigs to brodifacoum following baiting for rodent control

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G.A. Morriss, G. Nugent and P. Fisher

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G.A. Morriss, G. Nugent and P. Fisher

Landcare Research, PO Box 69, Lincoln 8152, New Zealand
morrissg@landcareresearch.co.nz

## ABSTRACT

As wide-ranging scavenging omnivores, feral pigs (*Sus scrofa*) are considered prone to secondary brodifacoum exposure when this persistent second-generation anticoagulant poison is used to control possums (*Trichosurus vulpecula*), especially in long-running ground-based baiting programmes. Currently in New Zealand, any detectable brodifacoum residues in pig meat for human consumption are considered unacceptable. To test whether brodifacoum could be used in control operations targeting rats (*Rattus rattus*), with reduced or no contamination of feral pigs, PESTOFF® rodent blocks (20-ppm brodifacoum) were used in nominally possum-proof bait stations, at Motatau Scenic Reserve, Northland. Snap-trapping indices of rat density carried out before and after baiting indicated that only about one-fifth of rats were killed, revealing low efficacy of this bait application. Sixteen radio-tagged wild-type pigs were released in the area and radiotracked to confirm their home ranges overlapped the poison area. After 2 months, 11 of the 16 released pigs, and five resident wild pigs, were killed and tested for liver brodifacoum residues. Five of the released pigs sampled had low liver concentrations (0.01–0.03 mg/kg), while one resident wild pig had 0.38 mg/kg brodifacoum in its liver, but none detected in muscle. Pigs apparently scavenged all of six Rhodamine-B-marked rat carcasses placed within the study area and four pigs, including one resident, were marked as a result. Although some brodifacoum contamination may have resulted from pigs scavenging possums rather than rats, the trial showed that some rats die above ground, and that pigs do scavenge rat carcasses. Compared with brodifacoum residue concentrations previously recorded in feral pigs (from the Vertebrate Pesticide Database), residues detected in pigs in this study were relatively low. However, even if rats can be successfully targeted by brodifacoum baiting, some contamination of feral pigs seems certain to occur, especially because higher rat kills than achieved in this study would present a greater availability of brodifacoum to feral pigs that scavenge rat carcasses.

Keywords: rats, feral pigs, residues, brodifacoum, baiting.



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# 1. Introduction

A trial was carried out to assess whether brodifacoum residues could be detected in free-ranging pigs following the use of brodifacoum baits in bait stations designed to target rodents but exclude possums.

# 2. Background

Brodifacoum is a highly effective anticoagulant toxicant for controlling brushtail possums (*Trichosurus vulpecula*) and rodents. However, brodifacoum is highly persistent, particularly in liver tissue, although residues in muscle tissue may also occur. In recent laboratory studies, sublethal brodifacoum residues in liver have been shown to bioaccumulate (Eason et al. 2003), so that repeated sublethal exposures could result in increased concentrations of residues which could, in turn, lead to adverse effects on animal health, reproduction or survival. Not surprisingly, sustained use of brodifacoum as a vertebrate pesticide in mainland sites has led to brodifacoum contamination in a range of non-target species, including harvested species such as feral pigs. The Vertebrate Pesticides Residue database (maintained for the Department of Conservation (DOC) by Landcare Research) includes records of brodifacoum residues found in wildlife species. The occurrence of brodifacoum residues in pigs, rodents, deer, possums and native bird species has also been described in a number of recent publications (Eason & Spurr 1995; Eason et al. 1996, 1999, 2002). As omnivorous scavengers, feral pigs (*Sus scrofa*) are considered particularly prone to secondary exposure to brodifacoum. Recent evidence of brodifacoum contamination in feral pigs harvested for meat (Clear 2003) indicates a potential risk to the small export market for wild pork, and raises concerns that recreational pig hunters may be put at risk from eating contaminated pork. The maximum residue level (MRL) for brodifacoum in meat is currently set by the New Zealand Food Safety Authority (NZFSA) at the analytical limit of detection (1 ppb).

In response to the concerns about brodifacoum residues in wildlife, in January 2000 DOC announced plans to reduce the field use of brodifacoum on mainland New Zealand. However, some application methods of brodifacoum products (e.g. Talon® and PESTOFF®) currently do not require user licensing and remain important components of on-ground and bait station possum control programmes in some regional pest management strategies. One of the strengths of brodifacoum has been its effectiveness against both rats and possums, both of which are conservation pests (e.g. Innes et al. 2004). While other methods, such as trapping and / or cyanide poison, may provide cost-effective alternatives for possum control, restrictions on the use of brodifacoum have significantly reduced the available options for cost-effective, ground-based control of rats.

This trial aimed to determine whether the risk of secondary exposure to pigs could be reduced by targeting rodents using brodifacoum baits that were fixed in place inside bait stations. This was expected to minimise primary exposure of pigs to bait, as the baits could not easily be removed and cached by rodents or spilt from the bait station by possums. Further, the expectation was that the risk of secondary exposure would be greatly reduced, because few possum carcasses containing brodifacoum would be available for scavenging by pigs, and the biomass of brodifacoum-containing rodent carcasses available to pigs would be small (because of their small body size and because we suspect that most die in nests out of reach of pigs).

# 3. Objectives

- To assess the concentrations of brodifacoum residues in free-ranging pigs from an area where rats were targeted with brodifacoum baits fixed in place inside bait stations.
- To determine the efficacy of this baiting application in controlling a population of rats (*Rattus rattus*).

# 4. Methods

The project was conducted at Motatau, Northland (Fig. 1), where there was a small resident population of pigs. The Motatau Scenic Reserve and the area of pine forest immediately north has a bait station grid established over greater than 400 ha, but brodifacoum had not been used there since before 2000 (G. Coulston pers. comm.). The study site was mostly surrounded by cleared farmland or pine forest, owned by either Carter Holt Harvey or Prime Holdings (Kevin Prime, Ngati Hine kaumatua), and hunting access to the reserve is tightly controlled. Possums at the site were poisoned in December 2002 (using Feratox® and FeraCol®), resulting in a Residual Trap Catch Index (RTCI) of 3% (G. Coulston pers. comm.). Although it is likely FeraCol killed some rats, we expected rat numbers to still be quite high by the time this trial was initiated in autumn 2003. To confirm this, rodent abundance was assessed using snap trapping as an index of rat density (see section 4.1), and the results were reported immediately to DOC in order to gain their approval to continue with the trial (E. Murphy, pers. comm. 5 May 2003).

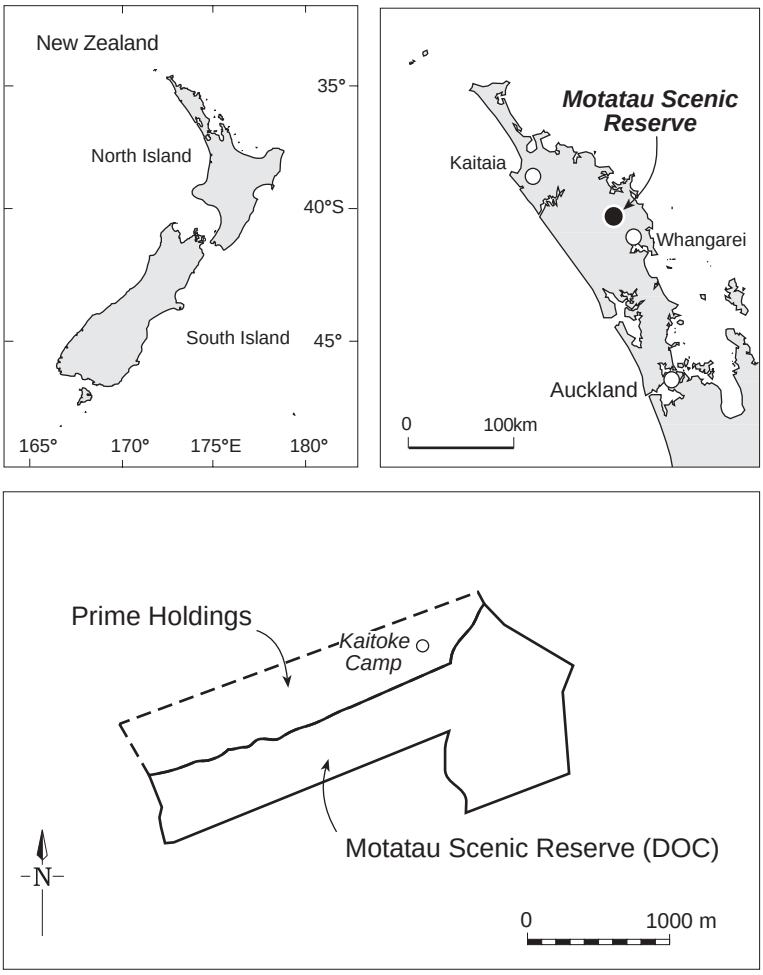


Figure 1. Motatau Scenic Reserve, Northland. Area applied with pesticide outlined in solid line (DOC land) and dashed line (Prime Holdings).

## 4.1 RODENT POISONING AND MONITORING

We measured the index of rat density 2 weeks before baiting (30 April – 2 May 2003) and immediately after (15–18 July 2003), using three randomly located lines of 20 Victor snap traps in corflute tunnels set at 20-m intervals. The traps were baited with a combination of peanut butter and rolled oats and set for three fine nights. This method is based on that of Cunningham & Moors (1996), but differed in that one trap rather than two was used at each site. The rat kill achieved by the baiting operation described below was calculated, using the number of trap nights, taking account of the number of escapes and sprung traps on each of the three trap lines, based on the method described by the National Possum Control Agencies (2001). Rats trapped before and after baiting were retained in frozen storage for residue analysis.

Rats were poisoned using 35-g PESTOFF® rodent blocks containing chocolate lure and a nominal 20 ppm brodifacoum (20 mg/kg; Animal Control Products, Wanganui) in Philproof bait stations. We used 240 existing bait stations established for previous possum control. These were spaced at 100-m intervals along parallel transects 150 m apart, with 160 in the northern part of the scenic reserve, and 80 in pine forest owned by Prime Holdings immediately north of the reserve (Fig. 1). Philproof Pest Control Products were contacted regarding modifications to the bait stations that would make them rodent-specific. They

recommended adding four, 100-mm, feathered (rough-edged) plastic spikes in each of the bait station bases, on which the rodent bait blocks could be threaded by a central hole and held in place. In this trial we used this method with two blocks fixed on each spike (eight blocks per station). Two weeks after all bait stations had been filled in the initial pulse, bait blocks eaten were counted and any missing blocks replaced. Three weeks after rebaiting, remaining bait was removed and the total amount taken by animals was calculated.

Six adult laboratory rats (surplus to requirements at the Landcare Research animal facility, Lincoln) were killed with carbon dioxide and frozen whole. When defrosted, the carcasses were injected with the marker dye Rhodamine B (2 mL of 50:50 solution of rhodamine and methanol) and placed at random sites within 500 m of each pig release site. Each rat carcass was placed on ground that was cleared and raked smooth over a 1.5 × 1.5 m area so that tracks of scavengers could be observed and recorded. The fate of these rat carcasses was monitored daily for the first week and then weekly for 3 weeks, to determine whether or not they were scavenged by pigs.

## 4.2 PIG MONITORING

Prior to baiting, seven wild pigs from the study site were hunted and killed, and their livers sampled for analysis for brodifacoum residues. Once initial rodent monitoring was completed, 16 young male wild-type pigs (15–25 kg; supplied by Arthur Swinbank, Tirau) were transported to the study site and ear-tagged with whip antenna transmitters attached to cattle ear tags (supplied by Sirtrack, Havelock North). Each pig was then weighed and randomly allocated into one of four groups. The four groups were then released into the treated area with at least 500 m between release points, two days after bait application commenced. A liver sample from a littermate of the released pigs was also taken for brodifacoum analysis; unfortunately, this sample was later destroyed during a freezer malfunction.

The released pigs were monitored weekly for up to 8 weeks by ground-based radiotracking, using a TR4 receiver and hand-held Yagi aerial. Close tracking of pigs was avoided as much as possible to limit disturbance. Any signal determined to be within the poison area was recorded as such, while pigs near to the boundaries of the block or outside of the study area were tracked more closely, to determine as accurately as possible how much time they had spent in the study area. About 8 weeks after release, the radio-tagged pigs were tracked down and either shot with a centrefire rifle or caught by trained pig dogs and killed with a knife in the heart. Liver, muscle and fat samples were taken and stored frozen for later analysis. In addition, pieces of skin with intact whiskers from around the snout of each pig were collected to check for marking indicating consumption of the rhodamine-containing rat carcasses. Five resident wild pigs were also killed and sampled at the same time or soon after (within one month) the released pigs were recovered, using the same methods as above.

## 4.3 BAIT AND TISSUE ANALYSES

All analyses were carried out at the Landcare Research toxicology laboratory, Lincoln. The brodifacoum concentration in a sample of bait was analysed using an IANZ-accredited method of high-performance liquid chromatography (HPLC) with fluorescence detection (Laboratory method TLM017 with a method uncertainty of ± 7%) to ensure the nominal concentration (20 ppm) was valid. A sample of cereal bait was ground in a Retsch mill and a 5-g subsample was weighed into a centrifuge tube. Anhydrous sodium sulphate was added and the mixture shaken for 10 min and centrifuged. The mixture was extracted twice more and a small aliquot of the combined extract was filtered and diluted in methanol for HPLC analysis. The analysis was carried out on a liquid chromatograph equipped with an Alltech Econosil 5-µm C18 column (250 mm × 4.6 mm), a fluorescence detector, and a post-column reagent pump. Difenacoum was used as an internal standard for improved quantification. A post-column pH switching technique using 10% ammonia and 10% methanol as the post-column reagent was used to exploit the natural fluorescence of the rodenticides.

Analyses for brodifacoum residues in pig tissues were undertaken using laboratory method TLM070 with a detection limit of 0.005 mg/kg. The HPLC was equipped with an Alltech 250 × 4.6 mm, 5-µm Econosil C18 column fluorescence detector, and post-column reagent pump. Aliquots of the sample were chromatographed on an Alltech Econosil, using acidified methanol and water as the mobile phase. The post-column reagent was ammonia/methanol/water (10:10:80). The flow rate of the ammonia solution was adjusted until the effluent had a pH of approximately 10.1. The HPLC was run at a flow-rate of 1.5 mL/min with helium sparging, using a gradient programme of: initial 65% A, 35% B; 5 min 84% A, 16% B; 10 min 95% A, 5% B; 15 min 95% A, 5% B; and 21 min 65% A, 35% B. The fluorescence detector was set at an excitation wavelength of 310 nm, with an emission wavelength of 390 nm, a gain of ×1000 and a filter setting of 1.5 for the Waters system. The retention time was 12–14 min. For the mobile phase, 2.50 mL of glacial acetic acid was added to HPLC methanol to 1 L and filtered through a 0.22-µm filter, and 1.25 mL of glacial acetic acid was added to deionised water to 500 mL and filtered through a 0.45-µm filter. The residue results were compared with existing data for pigs in the Vertebrate Pesticides Residue database.

Whiskers were carefully plucked from pieces of pig snout skin to ensure the whisker base (bulb) remained intact. These complete whiskers were examined to determine if any fluorescent bands were present as a result of exposure to rhodamine dye, using the method described by Spurr (2002). Observations of whisker samples were carried out by an experienced technician using a Zeiss Photomicroscope III fitted with Incident Light Fluorescence equipment and a high-performance filter set for TRITC and RB 200, comprising band pass interference exciter filter BP546/12, barrier filter LP590, and chromatic beam splitter FT580. A ×2.5 objective was used throughout. At least 10 whiskers were examined from each pig. As this marker method has not been calibrated on pigs, further samples of whiskers were examined from two pigs known to be unexposed to rhodamine, to provide a control reference for naturally occurring fluorescence.

# 5. Results

## 5.1 RODENT MONITORING AND BAITING EFFICACY

A total of 125.4 kg of bait was placed in bait stations, of which most (124.6 kg, 99%) was removed by animals over 5 weeks. This equated to 0.4 kg of bait eaten per hectare. There was minimal bait spillage, with only crumbs observed beneath some bait stations. Despite our intention to prevent possums from gaining direct access to the bait, four possum carcasses were found during fieldwork after baiting, suggesting that some of the bait was accessible to possums. It appears that the front two spikes in the vestibule part of the Philproof bait stations were probably still within reach of possums, so as much as 50% of the bait may have been taken by possums. However, this was considered unlikely because of the low possum density at the site, as determined by RTCI monitoring the previous summer. Three rat carcasses were also found on the forest floor during post-poisoning fieldwork, and a fourth was found in one of the bunkrooms at the Kaitoke Camp (June 2003), within the study site (see Fig.1). These carcasses were too decomposed for residue analysis.

Before baiting, a rat snap-trap index of 17% was recorded, declining to 14% in the week after baiting ceased, indicating a 19% reduction in rat numbers. As a consequence of this apparently low kill, and in consultation with DOC S&R staff, it was decided not to analyse the liver samples from rats captured in post-baiting monitoring for brodifacoum. However, these samples have been retained in storage and could be analysed in future to provide an indication of the concentrations and amounts of brodifacoum that were potentially available to feral pigs in the site. Five of the six rhodamine-injected rat carcasses were completely removed within a week (three in the first night), and the sixth was partially eaten by the second week. The partial carcass remained untouched during the rest of the trial. Pig prints were present around all six carcass sites, indicating that pigs were the most likely scavengers.

## 5.2 PIG MONITORING

The fate of the 16 radio-tagged male pigs released on 19 May 2003 at the Motatau site is summarised in Table 1. Most released pigs remained in the study site for the 7 weeks of the trial, but one group of four pigs (Far East Group) was never re-located after release, either because they had moved completely out of radiotracking distance or (more likely) they had been killed by poachers.

The Far West and Middle groups joined together within 3 days of release, and within 5 weeks one of the Kaitoke group (no. 20) had also joined them. Two months after release all remaining detectable radio-tagged pigs had joined together in one group. At the end of the trial, 11 pigs were recovered from this group. The radiotransmitters on three of these 11 were no longer working and a

fourth pig had completely lost its transmitter. We presume that these pigs were likely to have stayed in the company of the other pigs in their group, and therefore had the same amount of exposure to the poisoned carcasses. The large 'final' group moved completely outside the study area in the week prior to study completion, so the 'exposure' time for most of the recovered pigs was about 7 weeks (Table 1).

## 5.3 BAIT AND TISSUE ANALYSES

The baits used in the operation had a brodifacoum concentration of 19 ppm (mg/kg), compared with the nominal 20 ppm. This was within the acceptable range. Seven resident wild pigs sampled from the study site prior to brodifacoum baiting had no detetacle brodifacoum residues in liver, with all samples below the method detection limit (MDL) of 1 ppb (or 0.001 μg/g). Five of the 11 released pigs (45%) had brodifacoum liver residues ranging between 0.01 and 0.03 μg/g (or 10 and 30 ppb). Because these brodifacoum concentrations were only slightly above the detectable limit of the analytical method used, and because the limited data on the ratio of brodifacoum liver residues to meat (muscle) residues generally indicates that meat residues would be approximately one-tenth of liver levels, the muscle and fat samples from these pigs were not analysed because they were not expected to have detectable concentrations of brodifacoum. In contrast, one of the resident pigs (a 45-kg adult male) had a relatively high liver brodifacoum concentration of 0.38 μg/g (Table 2). Although bleeding disorders and death occurred in 2 out of 36 possums with brodifacoum liver concentrations of 0.1 μg/g, (Eason et al. 2001), this pig was apparently healthy when captured. The muscle sample from this pig was analysed, but no residue was detected.

TABLE 1. FATE OF 16 RADIO-TAGGED MALE PIGS RELEASED AT MOTATAU ON 19 MAY 2003.

| GROUP | TAG NUMBER | PERIOD TRACKED (WEEKS) | EXPOSURE TIME (WEEKS) | FATE |
|---|---|---|---|---|
| Middle | 2 | 8 | 7 | Shot & sampled |
| Kaitoke | 4 | 7 | 7* | Shot & sampled |
| Middle | 6 | 8 | 7 | Shot & sampled |
| Middle | 8 | 8 | 7 | Shot & sampled |
| Far East | 10 | 1 | 1 | Not recovered |
| Far East | 12 | 1 | 1 | Not recovered |
| Far East | 14 | 1 | 1 | Not recovered |
| Far West | 16 | 8 | 7 | Shot & sampled |
| Kaitoke | 18 | 7 | 7* | Shot & sampled |
| Kaitoke | 20 | 7 | 7* | Not recovered |
| Far West | 22 | 8 | 7 | Shot & sampled |
| Far West | 24 | 8 | 7 | Shot & sampled |
| Far West | 26 | 4 | 7* | Shot & sampled |
| Far East | 28 | 1 | 1 | Not recovered |
| Kaitoke | 30 | 8 | 7 | Shot & sampled |

Note: The 'period tracked' column indicates the length of time between first and final radiolocations. 'Exposure time' indicates the time the pig was considered to have spent within the poisoned area, with the asterisks indicating where this estimate is based on the assumption that the pig had remained in the company of its group mates.

We detected rhodamine marking in whiskers of three of the 11 released pigs sampled, two from the Middle group and one from the Far West group (Tables 1 and 2). Only one of these, however, had liver brodifacoum residues above the MDL. The whiskers from the resident wild pig with high brodifacoum residues were also marked, indicating that truly wild pigs will also scavenge rat carcasses that are available on the ground.

# 6. Conclusions

It is unclear why the measured rat kill was so low. Previously, brodifacoum poisoning at Motatau using exactly the same bait station network had been effective in maintaining very low rat numbers (as indexed by tracking-tunnel rates of near zero; Innes et al. 2004). A possible explanation is that we used too little bait (approximately 0.28 kg at any one time in each bait station). Previous rat control at Motatau (January 1998) used 1 kg of PESTOFF® brodifacoum bait

TABLE 2. BRODIFACOUM CONCENTRATION IN PIG LIVER, AND RHODAMINE MARKING OF PIGS SAMPLED AT MOTATAU SCENIC RESERVE, NORTHLAND.

| IDENTIFICATION/ TAG NUMBER | BRODIFACOUM RESIDUE (µg/g) | RHODAMINE MARKING (Y/N) |
|---|---|---|
| Before baiting | | |
| Pig (wild) | < MDL | N/A |
| Pig (wild) | < MDL | N/A |
| Pig (wild) | < MDL | N/A |
| Pig (wild) | < MDL | N/A |
| Pig (wild) | < MDL | N/A |
| Pig (wild) | < MDL | N/A |
| 18-kg boar (wild) | < MDL | N/A |
| After baiting | | |
| 2 | 0.03 | N |
| 4 | 0.01 | N |
| 6 | < MDL | N |
| 8 | < MDL | Y |
| 16 | < MDL | N |
| 18 | < MDL | N |
| 22 | 0.01 | Y |
| 24 | 0.03 | N |
| 26 | < MDL | N |
| 30 | 0.01 | N |
| 32 | < MDL | Y |
| Piglet (wild, < 1 month) | < MDL | N/A |
| 45-kg boar (wild, 1–2 year) | 0.38 | Y |
| 45-kg sow (wild, 1–2 year) | < MDL | N/A |
| 27-kg boar (wild, 0.5–1 year) | < MDL | N/A |
| 23-kg boar (wild, 0.5–1 year) | < MDL | N/A |

N/A = Not assessed
< MDL = Below method detection limit

in an initial pulse. In that study possum numbers were moderate (10% RTCI) and rat numbers low (tracking indices < 10%), therefore most bait would probably have been taken by possums. Follow-up pulses of 0.3–0.5 kg (March, May, August, and November 1998) continued to suppress both rat and possum populations. In this trial, the quantity of bait available to rats would have been further reduced if possums removed most of the bait on the front two of the four spikes in each station. With the unforeseen possum bait take, the quantity of bait remaining in stations may have been insufficient to present all rats with a lethal exposure, or rats may have had ample alternative food and been less inclined to take bait. Whatever the cause of the reduced rat kill, the 19% decline in the trapping index and the finding of three rat carcasses above ground in the forest indicate clearly that some rats were poisoned and were available to be scavenged by pigs. In this regard, the low kill did not compromise the planned experiment. However, feral pigs were probably presented with fewer contaminated rat carcasses than would be available following a baiting operation with a higher kill of rats.

The finding that some possums were also killed means that our residue findings must be interpreted in the context of a reduced, rather than zero, possum kill. However, there are good grounds for believing that the number of possums killed was very low, as the December 2002 possum density was low (3% RTCI). Exclusion of possums in the future will require either redesign of the bait station (by shifting back or removing the front two spikes) or a shift to a more rat-specific device such as an artificial rat-sized tunnel.

Residues were detected in the livers of 45% of the released pigs in this trial, but the average residue concentration in these pigs was very low compared with the results of previous monitoring of brodifacoum residues in wild pigs. Using information from the Vertebrate Pesticides Residues database, Eason et al. (2002) reported that 60% of a sample of feral pigs collected live (except one) from areas where brodifacoum was being used for possum and rat control had detectable residues of brodifacoum in their livers. The average concentration in the livers of these pigs was 0.46 mg/kg (range 0.007–1.900 mg/kg), compared with an average of 0.011 mg/kg for released pigs in this study (assuming, as a worst-case scenario, a concentration of 0.005 mg/kg for the six pigs with liver residues below the MDL). Compared with brodifacoum residue concentrations previously recorded in feral pigs (from the Vertebrate Pesticide Database), residues detected in pigs in the present study were relatively low. However, brodifacoum had been applied in the other areas at, on average, ten times the rate of that used at Motatau (4.0 kg/ha cf. 0.4 kg/ha) and for greater periods of time (several years cf. 2 months).

The consistency in the low levels of residue in the released pigs is at odds with the high level in the one contaminated wild pig. This major difference between pigs appears unlikely to have been the consequence of eating vastly different numbers of rat carcasses, as the six carcasses spiked with rhodamine were probably eaten by at least four different pigs (three released, one resident) from three different groups (counting resident wild pigs as a fifth 'group'). We speculate that the wild boar was contaminated through feeding on one or more contaminated possum carcasses, or through exposure to bait crumbs spilled from bait stations. Of course, it is also possible that this pig was not contaminated at Motatau at all, but picked up the residues elsewhere, as pig

movements of up to 35 km have been recorded in New Zealand (Nugent et al. 2003). However, even if rats can be successfully targeted (and possums excluded) by brodifacoum baiting, some contamination of feral pigs seems certain to occur, especially because higher rat kills are expected to present a greater availability of brodifacoum to feral pigs that scavenge rat carcasses. The extent to which an effective rat kill with brodifacoum baits (e.g. > 90% population reduction) would result in contamination of feral pigs is not known. This needs to be investigated, with especial consideration of the occurrence of detectable brodifacoum residues in the muscle tissue of feral pigs, and the subsequent potential for human consumption of this brodifacoum in recreationally-hunted meat.

In summary, we are confident that some rats were killed in our trial, and field observations showed that some rats died above ground. The marker data suggest that many of the rats that died above ground were likely to have been scavenged by pigs. This finding is consistent with recent findings from two separate trials that pigs found and scavenged most possum carcasses placed within their home range (Nugent et al. 2003). Nugent et al. (2002) reported finding rodent remains in a quarter of the stomachs of 20 pigs from native forest on the West Coast.

Although Rhodamine B has been used as a systemic bait marker in a variety of mammal species (Fisher 1999), this study was the first attempt we are aware of to use it as a systemic marker for pigs. Our apparent success in detecting marking in four pigs when only six 'baits' were available suggests that this may be a highly sensitive and useful tool for quantifying bait acceptance by pigs in future studies; for example, to determine bait coverage in relation to pig home range.

# 7. Recommendations

- Possum-proof bait stations for rodents should continue to be developed and / or tested. However, this is only worth doing if some low level of residue in pork is acceptable, because even if no possums are killed, pigs will find and scavenge some poisoned rat carcasses and become contaminated.
- For the same reasons, the timing and frequency of use of brodifacoum in bait stations in areas where pig hunting occurs needs to be carefully considered, as we believe that it is not possible to eliminate the risk of secondary exposure of pigs to brodifacoum from poisoned rats.
- Alternative, less persistent anticoagulants should be considered for use in rodent control in areas where feral pigs are present, and residues of these assessed in pigs and other wildlife.
- Further calibration of the Rhodamine-B marking method in pigs would provide a useful technique for field studies of bait uptake in this species.

# 8. Acknowledgements

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