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SHORT COMMUNICATION

BRODIFACOUM RESIDUE ANALYSIS IN WATER, SOIL, INVERTEBRATES, AND BIRDS AFTER RAT ERADICATION ON LADY ALICE ISLAND

Summary: Rats were eradicated from Lady Alice Island (Northland, New Zealand) in October 1994, using aerially applied cereal-based bait containing brodifacoum. To determine the fate and non-target impact of brodifacoum, streams, soil, invertebrates, and birds were monitored for 7 months after the baits were applied. No brodifacoum was detected in any of the stream or soil samples. Brodifacoum was detected in cave weta found on baits, and in morepork and red-crowned parakeet liver tissue. Significant contamination of water and soil is unlikely after a single aerial application of brodifacoum baits. Invertebrates such as cave weta may be at risk of consuming brodifacoum bait, morepork and red-crowned parakeet may be at risk of secondary poisoning.

Keywords: Brodifacoum; non-target impacts; pest control technology; environmental contamination.

Introduction

Brodifacoum, a potent second-generation anticoagulant rodenticide, has been used successfully in rodent eradication operations on islands in New Zealand. The control operations were to protect threatened species and restore island ecosystems (Taylor and Thomas, 1989, 1993; Robertson *et al.,* 1993; Towns *et al.,* 1993).

Brodifacoum is extremely insoluble in water (<10 mg/litre of water at pH 7). When baits disintegrate, brodifacoum is likely to remain in the soil where it may be slowly degraded by micro-organisms. The half-life of brodifacoum in soil under aerobic conditions is reported to be 157 days (WHO, 1995).

While the risk to non-target species of primary poisoning from brodifacoum baits in bait stations is considered relatively low, aerial application puts non-target species, particularly ground-feeding birds, at a potentially greater risk (Robertson *et al.,* 1993; Towns *et al.,* 1993).

A major operation using aerially applied cereal baits containing brodifacoum was undertaken to eradicate kiore (*Rattus exulans* Peale) from the broadleaf and shrubland habitats of 120 ha Lady Alice Island, Northland, New Zealand on 27 October 1994. The operation was successful, killing all of the rats on the island (K. Hawkins, Department of Conservation, pers. comm.).

This research note reports results of residue analyses undertaken on water and soil, and on invertebrate and bird tissues after the operation on Lady Alice Island. The analyses were undertaken to investigate the extent of environmental contamination under field conditions and non-target risks after aerial application of brodifacoum baits.

Methods

Cereal-based pellets containing 20 ppm brodifacoum (Talon® 20P) (ICI Crop Care, Richmond) were aerially applied by helicopter over Lady Alice Island at a rate of 12 kg ha^{-1} on 27 October 1994.

Water samples (100 mL) were randomly taken from streams before and 2, 12, and 34 days after the poison operation. Soil samples were taken from random sites on the island before and 2, 12, 34, and 210 days after the poison operation. At these same times, 5–10 live tree weta (*Hemideina thoracica* White) and 5-10 live cockroaches (Blattidae) were collected by hand. An individual cave weta (*Gymnoplectron* spp.) and black beetles (Coleoptera) found alive on baits were also collected. The island was searched for dead birds. A morepork (*Ninox novaeseelandiae* Gmelin) was found 23 days after the poison application, and a juvenile kakariki (red-crowned parakeet, *Cyanoramphus novaezelandiae* Sparrman) 33 days after. All samples were stored at -20°C for later brodifacoum residue analysis.

Five samples of water, five samples of soil, five individual tree weta, cave weta, and cockroaches

from each time, and liver tissue from the morepork and kakariki were analysed for brodifacoum content, using high-performance liquid chromatography (HPLC) with fluorescence detection developed from the method of Hunter (1983). Liver tissue was taken from the morepork and kakariki and also analysed for brodifacoum residues. For this tissue and soil, a 2 g sample was homogenised with 10 g of anhydrous sodium sulphate and 15 ml of chloroform/acetone (1:1), which was then shaken and centrifuged. The extract was decanted, evaporated, and taken up in hexane/chloroform/acetone (15:4:1) for clean-up in a Pharmacia SR10/50 gel permeation column filled with BioRad SX-3 biobeads. The eluent from the column was evaporated and taken up in methanol (0.5 ml) for HPLC analysis. Water samples were filtered, passed through a 100 mg solid phase extraction cartridge, and the eluent was evaporated and taken up in methanol (also 0.5 ml) for HPLC analysis. The HPLC method utilised a Brownlee 5 μm Spherisorb RP18 column (220 mm + 4 mm), using reverse-phase separation with an eluent of methanol/water containing 0.25% acetic acid, with a gradient programme running from 65% methanol to 85%, to 95% in 5-min stages. A flow rate of 1.5 ml/min was used, and a post-column reagent of 10% ammonia and 10% methanol in deionised water was added at 0.4 ml/min to give a final pH of 10.1. Retention time was 13.8 min, and the fluorescence detector was set at an excitation wavelength of 310 nm, and an emission wavelength of 390 nm. The limit of detection was 0.004 $\mu g\ g^{-1}$ in liver tissue, 0.02 $\mu g\ g^{-1}$ in soil and invertebrate tissue, and 0.0001 $\mu g\ g^{-1}$ in water.

Results

There was no brodifacoum detected in any of the water or soil samples. There was also no brodifacoum detected in any of the randomly sampled tree weta or cockroaches, or in the black beetles found on baits. However, 4.3 $\mu g\ g^{-1}$ of brodifacoum was detected in the cave weta found on baits, 3.4 $\mu g\ g^{-1}$ in the morepork liver tissue, and 0.03 $\mu g\ g^{-1}$ in the kakariki liver tissue.

Discussion

The lack of brodifacoum in the water and soil samples suggests that significant contamination of these environmental components is unlikely after a single aerial application of brodifacoum baits. However, brodifacoum has been shown to have strong soil adsorption properties and is effectively immobile in soil (WHO, 1995). It is possible, therefore, that brodifacoum could have persisted in soil only in localised areas, immediately around baits. Brodifacoum may not have been found in soil in the present study because none of the randomly chosen sample sites coincided precisely with bait sites.

The presence of brodifacoum in the tissues of cave weta that were found on baits is an indication that invertebrates such as these may be at risk of brodifacoum toxicosis. It has been suggested, however, that anticoagulants are unlikely to affect invertebrates because they do not have the same blood clotting systems as vertebrates (Shirer, 1992). This suggestion is supported by Morgan *et al.* (1996), who found that brodifacoum had no significant effect on large-headed weta (*Hemideina crassidens* Blanchard) when orally dosed.

A potential hazard is the secondary poisoning of warm-blooded animals which prey on invertebrates and/or rodents that have consumed brodifacoum. This hazard was perhaps illustrated by the presence of brodifacoum in the liver tissue of the morepork. It is possible that the specimen sampled in the present study consumed prey that had eaten brodifacoum bait. This finding adds support to the suggestion of Eason and Spurr (1995) that morepork are a species at risk of secondary poisoning by brodifacoum. An additional morepork carcass was found 34 days after the rat control operation. The cause of death remains unknown as the carcass was too decayed to analyse for brodifacoum. However, the poisoning appeared to have little impact on the morepork population. Of four regular morepork roosts, three were still used by moreporks throughout the 1994-95 summer, and two were regularly and one intermittently throughout the 1995-96 summer.

The presence of brodifacoum in the kakariki liver is an indication that this species may also be at risk. To our knowledge, this is the first report of brodifacoum residues being found in kakariki. It is likely that this kakariki received brodifacoum from eating baits, as captive kakariki are known to eat cereal-based baits (Spurr, 1993). However, kakariki remain common on the island after the rat eradication programme.

An eradication operation is planned for Coppermine Island in 1997. As a part of this operation, we plan to extend the work presented in this paper by monitoring the leaching of brodifacoum into soil directly beneath baits, further collection of birds before and after future control operations, and determining the toxicity of brodifacoum to captive kakariki.

Acknowledgements

This study was supported by the Foundation for Research, Science and Technology (C09632). We are grateful for the support of Andrea Booth (Massey University) and staff of the Department of Conservation, in particular the Whangarei field centre staff. Eric Spurr, Malcolm Thomas, Megan Ogle-Mannering, John Innes, and Trevor James are thanked for reviewing and refereeing this paper, and Wendy Weller for final word-processing.

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