Notornis, 2006, Vol. 53: 235-239
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Mortality of northern New Zealand dotterels (*Charadrius obscurus aquilonius*) following an aerial poisoning operation

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Abstract The anticoagulant brodifacoum is widely used for the control and eradication of vertebrate pests in New Zealand. During poisoning operations with this toxin, some native birds eat baits and die. Because brodifacoum persists in the environment, other birds may suffer secondary poisoning from eating animals that have ingested the poison baits.We describe here high mortality of New Zealand dotterels (*Charadrius obscurus*) following an aerial brodifacoum operation at Tawharanui Regional Park, North Auckland, in 2004. At least 50% of the dotterels in the area at the time of the operation disappeared or were found dead; one bird found freshly dead had a high liver level of brodifacoum residue. Sandhoppers (*Talorchestia* spp.) are a common food item of New Zealand dotterels. Sandhoppers at Tawharanui ate baits and accumulated brodifacoum and provided a potential route for transmission of the toxin to dotterels. Three pied stilts (*Himantopus himantopus*) and one spur-winged plover (*Vanellus miles novaehollandiae*) were also found dead. These records appear to be the first to document probable secondary poisoning of shorebirds in New Zealand. There was no apparent mortality of variable oystercatchers (*Haematopus unicolor*). Measures are suggested to reduce shorebird mortality in future operations of this type. Monitoring of New Zealand dotterels and other shorebirds during other types of poisoning operations in coastal areas is also recommended.

Dowding, J.E.; Lovegrove, T.G.; Ritchie, J.; Kast, S.N.; Puckett, M. 2006.Mortality of northern New Zealand dotterels (*Charadrius obscurus aquilonius*) following an aerial poisoning operation. *Notornis 53*: 235-239.

Keywords brodifacoum; secondary poisoning; New Zealand dotterel; *Charadrius obscurus*; threatened species; sandhoppers; *Talorchestia*

INTRODUCTION

The second generation anticoagulant brodifacoum has been widely used in New Zealand for the control and eradication of vertebrate pests, particularly brushtail possums (*Trichosurus vulpecula*) and rats (*Rattus* spp.).

However, the use of toxic baits does pose risks to non-target species, including native birds. For example, ducks (*Anas* spp.), paradise shelducks (*Tadorna variegata*) and pukeko (*Porphyrio porphyrio melanotus*) eat the cereal (pollard) baits that are normally used in rodent control or eradication operations, and suffer primary poisoning (e.g., Eason & Spurr 1995, Dowding *et al*. 1999). There may also be indirect effects, when carnivorous

Received 1 December 2005; accepted 31 March 2006

or omnivorous birds eat animals that have ingested brodifacoum. Such secondary poisoning is well documented in New Zealand (Eason & Spurr 1995). Brodifacoum persists in the environment and accumulates in vertebrate tissues (particularly in the liver), with residues detected after 9 months in possums and feral cats (*Felis catus*) (Eason *et al.* 1996; Dowding *et al*. 1999). Invertebrates also eat baits containing brodifacoum. The toxin has no effect on some species, but is lethal to others, particularly some molluscs; similarly, it does not appear to accumulate in some species, but does in others (Booth *et al*. 2005).

This paper records high mortality of New Zealand dotterels at Tawharanui Regional Park, North Auckland, which appears to have been caused by secondary poisoning following a rat eradication operation. The northern New Zealand dotterel (*Charadrius obscurus aquilonius*) is a threatened, endemic plover with a population in Oct 2004 of about 1700 individuals (JED, unpubl. data). It is classified as Category 3 Nationally Vulnerable in the Department of Conservation's threat classification scheme (Hitchmough & Bull 2004); internationally, the species as a whole is ranked Endangered (BirdLife International 2006). Northern New Zealand dotterels breed around the coastline of the North Island, mainly on sandy beaches north of 39°S (Dowding & Moore 2006). The diet of New Zealand dotterels consists largely of aquatic and terrestrial invertebrates, live or recently dead, with small fish taken occasionally. On tidal estuaries, small crabs are an important part of the diet and on dry sandy beaches, sandhoppers (*Talorchestia* spp.) are a common prey item (Marchant & Higgins 1993).

STUDY AREA and METHODS

Tawharanui Regional Park (36°22′S, 174°50′E) is located at the eastern end of Tawharanui Peninsula, on the east coast north of Auckland. In 2003/04, an Xcluder™ predator-proof fence was installed across the peninsula to create the *c*. 530 ha Tawharanui Open Sanctuary. On 17 Sep and 21 Oct 2004, 'Pestoff' 20R pollard baits containing 20 ppm brodifacoum (Animal Control Products, Wanganui, New Zealand) were aerially applied to the area inside the fence at rates of 8 kg ha^{-1} and 7 kg ha^{-1} respectively. Following both poison drops, the park was regularly searched for dead birds. Birds found freshly dead were stored frozen for later dissection.

After it became apparent that New Zealand dotterels had died following the operation, sandhoppers were collected from Ocean Beach on 10 Feb 2005 for brodifacoum residue testing. Sandhoppers were chosen because (a) they are a favoured food item of New Zealand dotterels on sandy beaches, and (b) they are abundant among drift seaweed above the high-water line on the beaches at Tawharanui (Auckland Regional Council 2003). Sandhoppers were also held in captivity from 10 Feb 2005 and given access to toxic baits. Sand and drift seaweed containing sandhoppers were placed in a covered fish bin and 6 'Pestoff' 20R baits were added. Samples of sandhoppers were removed at 7 and 14 days for residue testing. Brodifacoum residue analysis was undertaken by the Toxicology Laboratory at Landcare Research, Lincoln.

The New Zealand dotterels at Tawharanui have been monitored since 1989, as part of a long-term study of demography and dispersal in the North Auckland area (Dowding & Chamberlin 1991; Dowding 1998a). Most birds at the site have been individually colour-banded. Before the first poison drop in Sep, 10 New Zealand dotterels were known to be resident at Tawharanui. These consisted of 3 pairs, 1 at Pukenihinihi Point (YM-YK & M-WKY), 1 at Jones Bay (M-OGO & M-BOR), and 1 on Ocean Beach (M-GKG & M-YWB). There were 4 unpaired birds on Ocean Beach, consisting of 1 adult female (M-WRO), 1 1st-year female (BW-RW), and 2 unbanded (UB) birds of unknown age and sex. In Oct, 2 further unbanded birds arrived and were seen at Anchor Bay and Ocean Beach. All the banded birds at Tawharanui visit the post-breeding flock at Omaha Spit, about 7 km to the north-west (Dowding & Chamberlin 1991).

Variable oystercatchers (*Haematopus unicolor*) have been colour-banded and monitored at Tawharanui since 1994. At the time of the 1st poison drop, there were 6 pairs resident at Tawharanui: M-KWY & M-OKG at Anchor Bay, M-WRB & UB at Jones Bay, M-WBY & M-BOK at Bluebell Point, M-BRY & UB at Pukenihinihi Point, and M-YRW & M-KOY and M-RGY & UB on Ocean Beach.

RESULTS

A large majority (>90%) of the 223 birds of 20 species found dead after the operation were waterfowl, pukeko or introduced passerines (Lovegrove & Ritchie 2005). However, there were also 8 shorebirds (suborder Charadrii), consisting of 3 pied stilts (*Himantopus himantopus*), 4 New Zealand dotterels, and 1 spur-winged plover (*Vanellus miles novaehollandiae*).

New Zealand dotterels

The fates (where known) of New Zealand dotterels at Tawharanui following the poison operation are shown in Table 1.

Table 1 Known fates of northern New Zealand dotterels (*Charadrius obscurus aquilonius*) resident at Tawharanui Regional Park, Auckland, New Zealand, following the aerial poisoning operation in Sep-Oct 2004. UB, unbanded.

Bird	Location	Sex	Fate	Date last seen alive	Date carcass found, condition	Brodifacoum residues
M-YWB	Ocean Beach	Female	Disappeared	14 Oct 04	–	–
M-GKG	Ocean Beach	Male	Disappeared	24 Nov 04	–	–
M-OGO	Jones Bay	Male	Died	24 Oct 04	21 Dec 04, desiccated	Not tested
M-BOR	Jones Bay	Female	Survived	–	–	–
BW-RW	Ocean Beach	Female	Died	14 Oct 04	12 Dec 04, desiccated	Not tested
UB	Ocean Beach	Female	Died	–	10 Dec 04, fresh	0.77 μg g^{-1}
UB	Ocean Beach	Unknown	Died	–	12 Dec 04, desiccated	Not tested
M-WRO	Ocean Beach	Female	Survived	–	–	–
YM-YK	Pukenihinihi Pt	Male	Survived	–	–	–
M-WKY	Pukenihinihi Pt	Female	Survived	–	–	–

In addition to the 4 New Zealand dotterel carcasses found, 2 other colour-banded birds disappeared and have not been seen subsequently, either at Tawharanui or at the local post-breeding flock site at Omaha Spit. Adult New Zealand dotterels have very high breeding-site and flock-site fidelity and highly predictable movement patterns (Dowding & Chamberlin 1991), suggesting that the 2 birds that disappeared also died. Minimum mortality of New Zealand dotterels at Tawharanui was therefore estimated at 50% (6 of 12 birds) within 3 months of the 1st poison drop. As noted below, the Pukenihinihi Point pair spent much of the 2004/05 breeding season outside the treatment area. These birds were therefore less likely to have been exposed to brodifacoum until at least a month after the 2nd drop; if they are excluded from the analysis, mortality was 60% (6 of 10 birds). Considering only colour-banded birds, mortality was 57% (4 of 7 birds).

Deaths are estimated to have occurred between mid-Oct (1 month after the 1st drop) and 8-9 Dec (7 weeks after the 2nd drop). There was no obvious bias between the sexes in mortality; of the 5 New Zealand dotterels of known sex that disappeared or died, 2 were males and 3 were females.

Only 1 of the 3 pairs present before the operation survived intact. On Ocean Beach, M-YWB disappeared between 14 and 17 Oct 2004. Her mate (M-GKG) subsequently re-paired with an unbanded female. He disappeared in mid-Nov, and the fate of the unbanded female is unknown. At Jones Bay, M-OGO had disappeared by mid-Nov. His mate of at least 11 years (M-BOR) abandoned their nest but remained at Tawharanui until early Jan 2005. She was later seen at her usual post-breeding flock site at Omaha Spit. By early Aug 2005, she had returned to Tawharanui, but was apparently still unpaired. At Pukenihinihi Point, YM-YK and M-WKY both survived the operation. Their 1st and 2nd breeding attempts (in Oct and Nov respectively) were outside (but adjacent to) the area covered by the poison drops. In Dec they nested again, this time inside the treatment area, and fledged 1 chick.

The dotterel population at Tawharanui recovered rapidly during the 2005/06 season. By late Jul 2005, YM-YK and M-WKY had reclaimed their territory. In early Aug, 2 new pairs (all 4 birds UB) appeared to be establishing territories on Ocean Beach. By early Nov, 6 pairs were breeding; M-BOR and a new mate had 2 chicks, and 5 pairs (YM-YK and M-WKY and 4 new pairs) had nests.

Variable oystercatchers

There was no indication that any variable oystercatchers died following the operation. No carcasses were found, and none of the 9 resident colour-banded birds disappeared.

Brodifacoum residues

The liver of the only New Zealand dotterel tested had a brodifacoum residue level of 0.77 μg g^{-1}. The liver of 1 pied stilt was tested and had a brodifacoum residue level of 0.92 μg g^{-1}. The liver of the spur-winged plover was not tested.

The sample of sandhoppers collected from Ocean Beach on 10 Feb 2005 had a low level of brodifacoum residue (0.01 μg g^{-1}), close to the limit of detection.

Captive sandhoppers began eating baits within 15 min of them being added. By the following day, baits had been pulled under the sand (to a depth of *c.* 10 mm) and sandhoppers continued to feed on them. Parts of baits were still present after 1 week, but all bait had been eaten by 2 weeks. A sample of sandhoppers taken at 1 week contained 0.21 μg g^{-1} brodifacoum residues; a 2nd sample taken after 2 weeks contained 0.19 μg g^{-1} residues.

DISCUSSION

Mortality of New Zealand dotterels of 50-60% in *c.* 3 months is extremely high, compared to the normal range of 6-9% per annum observed in this area from 1995-98 (Dowding 1998a). It therefore seems very likely that the poison operation was responsible for the deaths. The livers of the New Zealand dotterel and pied stilt tested had brodifacoum residue levels of 0.77 μg g^{-1} and 0.92 μg g^{-1} respectively. Based on a range of studies, Dowding *et al*. (1999) suggested that most birds with liver brodifacoum levels of 0.5 μg g^{-1} or more are very likely to have died of poisoning.

The diet of New Zealand dotterels consists almost exclusively of invertebrates, live or recently dead, with small fish taken occasionally (Marchant & Higgins 1993). This suggests that they are unlikely to eat cereal baits, so secondary poisoning is more likely than primary poisoning as a cause of death. The extended time over which New Zealand dotterels died or disappeared at Tawharanui is also consistent with secondary poisoning.

Our results show that shorebirds may be at risk of secondary poisoning during pest-control operations when baits containing anticoagulants are spread on the ground. In the case of New Zealand dotterels at Tawharanui, beach invertebrates (including sandhoppers) were potential vectors of the toxin. The fact that brodifacoum residues were still just detectable in sandhoppers collected more than 3.5 months after the 2nd poison drop shows that they may retain the toxin for a considerable period, or baits may remain available to them. Secondary poisoning of shorebirds has been recorded overseas (e.g., Godfrey 1985), but our records appear to be the first published for New Zealand shorebirds.

There is extensive overlap between territories of New Zealand dotterels and variable oystercatchers at Tawharanui, but there appeared to be no mortality of oystercatchers. There are 2 possible reasons for this. First, variable oystercatchers are larger (about 5× the mass of New Zealand dotterels on average) and would presumably require a larger absolute dose of toxin. Second, the two species have different diets; variable oystercatchers feed largely on bivalve molluscs (Heather & Robertson 1996), which are normally in the inter-tidal zone and/or deeper in the sand than sandhoppers and should therefore be exposed to much less toxin.

In contrast to the results reported here, an aerial brodifacoum operation on Motuihe Island apparently resulted in no mortality of New Zealand dotterels (Dowding *et al*. 1999). In hindsight however, there is an obvious difference between the 2 operations. Less bait was spread on Motuihe (applications of *c.* 6.2 and 3.5 kg ha^{-1}) (Veitch 2002), and almost no baits remained visible two days after the 2nd drop (Dowding *et al*. 1999). It seems likely that most of the brodifacoum sown on Motuihe was rapidly sequestered in large vertebrates (a very dense rabbit population and numerous waterfowl and pukeko) with very little available to the littoral invertebrates that form the bulk of the New Zealand dotterel's diet.

In most aerial brodifacoum operations there is mortality of birds, particularly ducks, paradise shelducks, and pukeko (e.g., Eason & Spurr 1995). However, populations of most species recover, and the long-term benefits of rodent-free habitats to many species are assumed to outweigh the short-term losses (Dowding *et al*. 1999, Empson & Miskelly 1999, Lovegrove & Ritchie 2005). However, it is clearly desirable during these operations to adopt techniques that reduce mortality of non-target species (and particularly of threatened species) as much as possible.

Where baits are aerially sown over beaches, they tend to roll down the slope of the fore-dunes and beach. Baits are also pushed up the beach by the first incoming tide after the drop. Together, these circumstances can result in a concentration of baits in a strip along and just above the high-water line (Dowding 1998b), exactly where sandhoppers are most common. There are 2 measures that could be taken to reduce mortality of northern New Zealand dotterels in future operations of this type. First, baits could be cleared by hand from beaches immediately after each drop. Priority should be given to areas that are known territories of New Zealand dotterels, and areas where there is cover for beach invertebrates, such as driftwood and seaweed. Our observation that captive sandhoppers pulled baits under the sand and continued feeding on them, suggests that this clearance needs to be undertaken quickly after each drop. Second, the use of digital GPS has made it possible to sow baits with high accuracy. It is now feasible to avoid dropping bait on beaches, and then cover required areas by hand-sowing or using bait stations along the rear of beaches or in dunes, avoiding the high-water line area. Both approaches seem advisable in future operations, i.e. aerial sowing of baits should avoid beaches, then a check on foot should be carried out and any baits that are found should be removed.

Because of the persistence of brodifacoum and the risks of accumulation in non-target species, its aerial application on the mainland is restricted (Environmental Risk Management Authority 2005). However, other toxins are used

in coastal areas on the mainland. In particular, the anticoagulant pindone is widely used to control lagomorphs in coastal dune systems. Although less persistent than brodifacoum, pindone is known to be toxic to birds (Martin *et al*. 1994; Eason & Wickstrom 2001). Beach invertebrates other than sandhoppers are presumably also potential vectors of these toxins. Secondary poisoning of shorebirds thus remains a possibility on the New Zealand mainland, and close monitoring of such operations now appears necessary. At Tawharanui, regular searches for dead birds and the presence of colour-banded birds allowed a reasonably accurate measure of the short-term impacts of the operation on New Zealand dotterels. Immigration of new pairs to the site was relatively rapid. At the majority of sites, few birds are likely to be banded; where this is the case or where monitoring is not intensive, shorebird mortality from poisoning could easily pass unnoticed. Even when survival is high, it is possible that there may be sub-lethal effects (e.g., on fertility); research is required on this topic.

ACKNOWLEDGEMENTS

Thanks to members of the Tawharanui Open Sanctuary Society, Inc., for undertaking searches for dead birds. For comments on the draft manuscript we are grateful to Elaine Murphy and Richard Holdaway.

LITERATURE CITED

Auckland Regional Council 2003. *Regional Parks Management Plan. Vol. 2.* Auckland, Resource Inventory, Auckland Regional Council, .

BirdLife International. 2006. http://www.birdlife.net/datazone/species/index.html

Booth, L.H.; Fisher, P.; Heppelthwaite, V.; Eason, C.T. 2001. Toxicity and residues of brodifacoum in snails and earthworms. *DOC science internal series 143*. Wellington, Department of Conservation.

Dowding, J.E. 1998a. Research on the impact of predation on New Zealand dotterels (*Charadrius obscurus*). *Report on Investigation no. 2051 to Science & Research Unit.* Wellington, Department of Conservation.

Dowding, J.E. 1998b. A radio-tracking study of feral cats on Motuihe Island. Unpubl. report to Auckland Conservancy. Auckland, Department of Conservation.

Dowding, J.E.; Chamberlin, S.P. 1991. Annual movement patterns and breeding-site fidelity of the New Zealand dotterel (*Charadrius obscurus*). *Notornis 38*: 89-102.

Dowding, J.E.; Moore, S.J. 2006. Habitat networks of indigenous shorebirds in New Zealand. *Science for conservation no. 261*. Wellington, Department of Conservation.

Dowding, J.E.; Murphy, E.C.; Veitch, C.R. 1999. Brodifacoum residues in target and non-target species following an aerial poisoning operation on Motuihe Island, Hauraki Gulf, New Zealand. *New Zealand journal of ecology 23*: 207-214.

Eason, C.T.; Spurr, E.B. 1995. Review of the toxicity and impacts of brodifacoum on non-target wildlife in New Zealand. *New Zealand journal of zoology 22*: 371-379.

Eason, C.T.; Wickstrom, M. 2001. Vertebrate pesticide toxicology manual (poisons) (2nd ed.) *DOC technical series 23*. WellingtonDepartment of Conservation.

Eason, C.T.; Wright G.R.; Batcheler, D. 1996. Anticoagulant effects and the persistence of brodifacoum in possums (*Trichosurus vulpecula*). *New Zealand journal of agricultural research 39*: 397-400.

Empson, R.A.; Miskelly, C.M.. 1999. The risks, costs and benefits of using brodifacoum to eradicate rodents from Kapiti Island, New Zealand. *New Zealand journal of ecology 23*: 241-254.

Environmental Risk Management Authority. 2005. Hazardous substances (Vertebrate toxic agents) transfer notice 2004 (amended 5 May 2005). Wellington, Environmental Risk Management Authority.

Godfrey, M.E.R. 1985. Non-target and secondary poisoning hazards of "second generation" anticoagulants. *Acta zoologica Fennica 173*: 209-212.

Heather, B.D.; Robertson, H.A. 1996. *The field guide to the birds of New Zealand*. Auckland, Viking.

Hitchmough, R.; Bull, L. 2004. Draft New Zealand threat classification systems lists 2004. Wellington, Department of Conservation.

Lovegrove, T.; Ritchie, J. 2005. Impacts of the aerial application of brodifacoum baits in September and October 2004 on bird populations at Tawharanui Regional Park. Unpubl. report to Auckland Regional Council, Auckland.

Marchant, S.; Higgins, P.J. (*ed*.). 1993. *Handbook of Australian, New Zealand & Antarctic Birds, Vol. 2. Raptors to lapwings*. Melbourne, Oxford University Press.

Martin, G.R.; Kirkpatrick, W.E.; King, D.R.; Robertson, I.D.; Hood, P.J.; Sutherland, J.R. 1994. Assessment of the potential toxicity of an anticoagulant, pindone (2-pivalyl-1,3 indandione), to some Australian birds. *Wildlife research 21*: 85-93.

Veitch, C.R. 2002. Eradication of Norway rats (*Rattus norvegicus*) and house mouse (*Mus musculus)* from Motuihe Island, New Zealand. pp. 353-356 *In*: Veitch, C.R.; Clout, M.N. (*ed*.). *Turning the tide: the eradication of invasive species*. IUCN Invasive Species Specialist Group. Gland, Switzerland and Cambridge, England, IUCN.