Toxicants for control of stoats *(Mustela erminea)*

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Abstract

The only toxicant currently registered in New Zealand for injecting into hen eggs for stoat control is sodium monofluoroacetate (1080). Of the potential toxicants, only diphacinone and cholecalciferol have been tested for stoat control. This report provides information on what form these toxicants come in, where to obtain them, how much is needed for a lethal dose, how to prepare solutions for injecting into eggs, and how much to inject into eggs. The options available for dyeing toxic eggs are also considered.

1. Introduction

Stoats *(Mustela erminea)* are major predators of New Zealand wildlife (O'Donnell 1996). The traditional method of stoat control is by trapping (King et al. 1994). A new method of control, using hen eggs injected with a toxicant, is currently being developed by Landcare Research for the Department of Conservation (Spurr 1996, 1998, Dilks 1997, King 1997, Miller & Elliot 1997, Spurr & Hough 1997). To date, three toxicants have been tested: sodium monofluoroacetate (1080), diphacinone, and cholecalciferol.

The Department of Conservation requested information on:

- What toxicants are available or potentially available for stoat control, including what form they come in, where to obtain them, how much is needed for a lethal dose, how to prepare solutions for injecting into eggs, and how much to inject into eggs.
- What options are available for dyeing toxic eggs used for stoat control.

2. Toxicants for stoat control

At present, the only toxicant registered with the Pesticides Board for stoat control in New Zealand is sodium monofluoroacetate (1080). Potential toxicants, registered in New Zealand for the control of a range of other vertebrate pests, that could be suitable for stoat control, include alpha-choralose, brodifacoum, bromadiolone, cholecalciferol, coumatetralyl, diphacinone, flocoumafen, and pindone. Other potential toxicants not currently registered in New Zealand include difethialone, strychnine, warfarin, and zinc phosphide. Wickstrom (1998) also identified methahaemoglobin-inducing agents and non-steroidal anti-inflammatory agents as possible mustelid-specific toxicants. Of the potential toxicants, only diphacinone and cholecalciferol have been tested for stoat control (Spurr 1996, 1998).

2.1 SODIUM MONOFLUOROACETATE (1080)

Sodium monofluoroacetate (1080) is a highly toxic pesticide, predominantly used in New Zealand for the control of brushtail possums *(Trichosurus vulpecula)* and rabbits *(Oryctolagus cuniculus)* (Eason 1997). As noted above, it is also registered for control of stoats. Because of its high toxicity it can be used only by licensed operators. There is no known antidote.

Pure 1080 is a whitish powder that is supposedly odourless and virtually tasteless (Rammell & Fleming 1978,Tomlin 1994, Eisler 1995). Commercially available 1080 has nigrosine dye added, making it black, and it has a faint vinegary smell (Rammell & Fleming 1978). It is about 98% pure. It is highly soluble in water and stable under normal storage conditions. It decomposes at about 200°C.

Animals that eat a lethal dose normally die from respiratory failure within 1-24 hours (Eisler 1995). Acute LD_{50} values range from <0.1 mg/kg to >100 mg/kg, but most are within the range of 1 to 10 mg/kg (Eisler 1995). The acute LD_{50} is 0.2-3.0 mg/kg for the Norway rat *(Rattus norvegicus)*, 0.3-1 .0 mg/kg for the brushtail possum, 0.42 mg/kg for the rabbit, 1.2-1.4 mg/kg for the ferret *(Mustela furo)*, and 0.49 mg/kg for the stoat (Rammell & Fleming 1978, Tomlin 1994, Eisler 1995, Spurr 1998).

The toxicity of 1080 to birds is similar to mammals; e.g., the LD_{50} for mallard ducks *(Anas platyrhynchos)* is 3.7-10.0 mg/kg (Eisler 1995). There is a risk of secondary poisoning to non-target species both from preying on live animals that have eaten toxic baits and from scavenging on carcasses of poisoned animals.

2.1.1 Availability of 1080

Compound 1080 is available (to licensed operators only) from Animal Control Products Ltd, Private Bag 3018, Wanganui, as a 20% stock solution (the standard), or a lower concentration may be specifically ordered. Landcare Research, Toxicology Laboratory, PO Box 69, Lincoln, will also supply solutions with a certified concentration of 1080.

2.1.2 Preparation of 0.1% solution

A 0.1% solution of 1080 is required for injecting into hen eggs for stoat control. You can purchase this directly (see above), or you can purchase a 20% stock solution and then dilute it to a 0.1% solution (e.g., see Table 1). Providing there is no spillage, 100 ml of 0.1% 1080 solution is enough for 100 eggs, 200 ml for 200 eggs, etc. Use a multiple of the amounts in Table 1 if you need to make more than 500 ml (e.g., twice 500 ml for 1000 ml).

Table 1. Recipe for making 100-500 ml of 0.1% solution from 20% stock solution of 1080.

Constituent	Amount (ml)	Amount (ml)	Amount (ml)	Amount (ml)	Amount (ml)
20% 1080 solution	0.5	1.0	1.5	2.0	2.5
Deionised water	99.5	199.0	298.5	298.0	297.5
Total	100.0	200.0	300.0	400.0	500.0

2.1.3 Amount to inject into hen eggs

Inject 1 ml of 0.1% 1080 solution (equivalent to 1 mg of 1080) into each egg (see Spurr & Hough 1997). Eggs must be dyed green first (see section 3 below). There is usually no need to seal the hole after injection, but if there is a risk of eggs becoming flyblown, then the hole can be sealed with nail varnish or candle wax.

2.2 DIPHACINONE

Diphacinone is a first-generation anticoagulant. It was developed originally as a rodenticide (Hone & Mulligan 1982, Buckle 1994, Tomlin 1994), and is registered with the Pesticides Board for rodent control in New Zealand. Diphacinone has been tested for stoat control (Spurr 1996, 1998), but is not currently registered for that purpose. It has an antidote (vitamin K), and can be used by the public.

Technical diphacinone is a yellow powder (usually about 95% pure). It is practically insoluble in water but soluble in propylene glycol and some other solvents (Tomlin 1994). It is stable for 14 days (at pH 6-9), but is rapidly decomposed in water by sunlight (Tomlin 1994). It decomposes at 338 °C.

Diphacinone inhibits the vitamin-K-dependent steps in blood clotting. Animals normally die from internal bleeding 3-11 days after they eat a lethal dose (Hone & Mulligan 1982). There is no evidence of aversion to diphacinone, so animals will continue to eat baits after they have ingested a lethal dose of the toxicant. The acute LD_{50} for the Norway rat is 2.3-43 mg/kg (Hone & Mulligan 1982, Buckle 1994, Tomlin 1994). There are insufficient data available to calculate an LD_{50} for stoats, but two stoats died after ingesting 3.2 mg of diphacinone, equivalent to 16 mg/kg for a 200g stoat (Spurr 1998).

The toxicity to birds is low; e.g., the LD_{50} for mallard ducks is 3158 mg/kg (Tomlin 1994). The risk of secondary poisoning to non-target species is also claimed to be low (Tomlin 1994), but birds of at least some species have died from secondary poisoning after eating diphacinone-poisoned rodents (Mendenhall & Pank 1980).

2.2.1 Availability of diphacinone

Diphacinone is currently not registered for stoat control. However, if an experimental use permit is obtained from the Pesticides Board, a 0.5% solution of diphacinone is available from Pest Management Services Ltd, PO Box 121, Waikanae. Providing there is no spillage, 100 ml of 0.5% diphacinone solution is enough for 200 eggs.

2.2.2 Preparation of 0.5% solution

A 0.5% solution of diphacinone is required for injecting into hen eggs for stoat control. This can be purchased directly (see above) so no preparation is necessary.

2.2.3 Amount to inject into hen eggs

Inject 1 ml of 0.5% diphacinone solution (equivalent to 5 mg of diphacinone) into each egg. Ensure that the solution is well mixed before using (shake if necessary).

2.3 CHOLECALCIFEROL

Cholecalciferol (Vitamin D_3) is toxic at high closes, and was originally developed as a rodenticide (Marshall 1984). It is registered in New Zealand for control of possums (Eason 1991, Eason et al. 1996), and has also been tested for control of stoats (Spurr 1998).

Technical cholecalciferol is an amber crystalline solid (Marshall 1984). It is nearly insoluble in water, slightly soluble in vegetable oils, and soluble in organic solvents. It has a melting point of 84-85°C. It is oxidised and inactivated by moist air within a few days. Commercially available cholecalciferol is a liquid concentrate specially formulated to overcome oxidation and ensure stability.

Cholecalciferol in toxic doses causes hypercalcaemia, osteomalacia, and metastatic calcification of the blood vessels (Marshall 1984, Marsh and Tunberg 1986). Tissue calcification occurs in the cardiovascular system, kidneys, stomach, and lungs. Death usually results from heart failure. Animals normally take 3-7 days to die (Marshall 1984, Marsh 8z Tunberg 1986, Jolly et al. 1995), but the compound has a stop-feeding action after about 24 hours. The acute LD_{50} is 43.6 mg/kg for Norway rats (Marshall 1984) and 16.8 mg/kg for possums (Jolly et al. 1995). The LD_{50} for possums is reduced to 9.8 mg/kg by the addition of calcium carbonate to baits (Jolly et al. 1995). The lethal dose for a stoat is about 100 mg, equivalent to about 500 mg/kg for a 200 g stoat (Spurr 1998).

The toxicity to birds is low; e.g., the LD_{50} for mallard ducks is 2000 mg/kg (Marshall 1984). The risk of secondary poisoning to non-target species is also low (Marshall 1984, Eason et al. 1996).

2.3.1 Availability of cholecalciferol

Cholecalciferol is currently not registered for stoat control. However, if an experimental use permit is obtained from the Pesticides Board, cholecalciferol is available from AgrEvo Pty Ltd, Newport, NSW, Australia, as a 37.5% stock solution. This has the consistency of a gel or syrup and needs diluting. It is also available from Feral Control, PO Box 58-613, Greenmount, Auckland, either as a powder or as a solution with a specified concentration.

2.3.2 Preparation of 20% solution

A 20% solution of cholecalciferol is required for injecting into hen eggs for stoat control. You can purchase this directly (see above) or you can purchase a 37.5% solution and then dilute it to a 20% solution (e.g., see Table 2). Providing there is no spillage, 100 ml of 20% cholecalciferol is enough for 200 eggs and 500 ml is enough for 1000 eggs. Use a multiple of the amounts in Table 2 if you need to make more or less than this.

Table 2. Recipe for making 100-500 ml of 20% solution from 37.5% stock solution of cholecalciferol.

Constituent	Amount (ml)	Amount (ml)	Amount (ml)	Amount (ml)	Amount (ml)
37.5% cholecalciferol solution	53.3	106.6	159.9	213.2	266.5
Soyabean oil	46.7	93.4	140.1	186.8	233.5
Total	100.0	200.0	300.0	400.0	500.0

2.3.3 Amount to inject into hen eggs

Inject 0.5 ml of the 20% cholecalciferol solution (equivalent to 100 mg of cholecalciferol) into each egg.

3. Options for dyeing hen eggs for stoat control

Hen eggs injected with 1080 for stoat control must, by law, be dyed green within the colour range 221 to 267 as described in the New Zealand Standards Specification 7702 (Pesticides (Vertebrate Pest Control) Regulations 1983, Spurr & Hough 1997). Brown egg shells and white eggs shells stain differently, so different dyes are needed for each. It is not possible to dye either brown or white eggs the correct shade of green using normal food dyes. However, brown eggs can be dyed correctly using a water-based clothing dye (Spurr & Hough 1997). This requires soaking the eggs in the dye solution for

4 hours. However, reports from the field indicate that eggs dyed in this way may decay within about 1 week. Undyed eggs are long-lasting and palatable to stoats for at least 1 month (Spurr et al. 1996, Spurr 1998). Subsequent consultation with egg producers has revealed that soaking eggs in an aqueous solution causes them to absorb water, resulting in rapid decay. Consequently, an alternative method of dyeing eggs is required. Options include dunking them in a dye solution for only a brief period of time (e.g., 5 minutes) or spraying them with a dye solution. The currently used clothing dye will not colour eggs the correct shade of green with either of these rapid dyeing techniques, so an alternative dye will be required.

A number of factors need investigating before selecting a new dye or new method of dyeing eggs. One is the influence of shell thickness on the rate of decay of eggs. There is some evidence that thin-shelled eggs, which are laid by older hens, decay more rapidly than thick-shelled eggs, which are laid by younger hens. Perhaps thick-shelled eggs can withstand soaking in water better, and therefore decay less rapidly, than thin-shelled eggs. Thus, a method of dyeing involving soaking eggs in a dye solution may be suitable for thick-shelled eggs. Shell thickness can be specified when purchasing eggs from a poultry farm but not from a supermarket. Thick-shelled eggs, however, may be more difficult than thin-shelled eggs for stoats, especially females, to break open, although this may not be a problem if the eggs are punctured. These factors need investigating urgently so that stoat control managers know before the start of the next stoat control season (November 1999) what sorts of eggs to use and how to dye them.

4. Discussion

The reliance on 1080 as the only toxicant registered with the Pesticides Board for stoat control is unwise. While 1080 is highly effective, its use is restricted because of its high toxicity. Diphacinone and cholecalciferol are alternatives to 1080 that have fewer restrictions on their use. Both have been shown to kill stoats (Spurr 1996, 1998), but neither currently registered with the Pesticides Board for this purpose. Diphacinone has already been used successfully (under an experimental use permit) to reduce stoat numbers in the field (Spurr 1996, 1998) and there should now be enough information available for it to be registered relatively easily. However, a perceived drawback of diphacinone is that it takes several days to kill stoats. During this time they may continue to prey on wildlife. Also, the persistence of diphacinone in animal tissue, and the risk of secondary poisoning, is unclear (Eason 1999).

Cholecalciferol may be a more suitable toxicant than diphacinone for stoat control because, although it may not kill stoats much more quickly, it causes them to stop feeding within 24 hours (Spurr 1998). Predation on wildlife is likely to be prevented after this time. Cholecalciferol is also less likely than diphacinone to cause secondary poisoning of non-target species. However, field trials will be needed before it can be registered with the Pesticides Board.

Other toxicants that could be suitable for stoat control (e.g., alpha-choralose, brodifacoum, bromadiolone, coumatetralyl, difethialone, flocoumafen, pindone, strychnine, warfarin, and zinc phosphide) need researching. The Department of Conservation is currently funding research on mustelid-specific toxicants (Wickstrom 1998, C.E. O'Connor, pers. comm.). In all cases, efficacy, effects on animal welfare, and environmental fate of toxicants will need to be considered.

5. Recommendations

- Diphacinone should be registered with the Pesticides Board for use in hen eggs for stoat control, using the supporting information currently available.
- Field trials should be undertaken to determine the efficacy of cholecalciferol in hen eggs for stoat control, to obtain supporting information for its registration with the Pesticides Board.
- New specifications should be developed urgently for dying hen eggs green, within the colour range 221 to 267 (New Zealand Standards Specification 7702) as required by the Pesticides (Vertebrate Pest Control) Regulations 1983, when using 1080 in hen eggs for stoat control.
- Research on mustelid-specific toxicants should be continued.

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