

Secondary poisoning risks from 1080 in carcasses

Charles Eason¹ Laurie Twigg² and Wayne Temple³

¹ CE Research Associates Limited

Auckland, New Zealand.

² Vertebrate Pest Research Section, Department of Agriculture and Food, Western Australia

³ National Poisons Centre, University of Otago, Dunedin, New Zealand

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Wellington

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Executive Summary

Sodium fluoroacetate (1080) has been used in New Zealand to kill animal pests, such as rabbits and possums since the 1950s. One of the key advantages of 1080 is that it is readily biodegradable. Sub-lethal doses are readily metabolized and excreted in animals. In contrast to some second generation anticoagulants 1080 does not bioaccumulate, however the slow breakdown of 1080 in possum carcasses under some circumstances and the risks of secondary poisoning remain a significant concern. In this short review we consider the following: i) the fate of 1080 in pest species ii) the risk of 1080 poisoned carcasses to dogs iii) possible exposure levels and risk of toxicity in other non-target species.

Studies focusing on the pharmacokinetics of 1080 have found 1080 to be metabolised and excreted from living animals. In possums that have been sub-lethally poisoned 1080 had a half-life of 9 hours, suggesting no significant amount of 1080 would be expected in the tissues of live possums 4 days after exposure. In contrast carcasses collected from the field were shown to pose a serious risk to dogs even up to 75 days after the poisoning operation. Dogs are a special case because of their unique sensitivity to 1080. When other species such as insects or birds come into contact with 1080 in poisoned carcasses sub-lethal poisoning is more likely. In these cases as with a sub-lethal poisoning of possums any 1080 ingested will be metabolised and excreted, and transfer through the food web will be minimal when compared to more persistent poisons used for possum control such as brodifacoum.

Introduction

Literature relating to the secondary poisoning risk of 1080 has been reviewed by Dr Charles Eason, Dr Laurie Twigg and Dr Wayne Temple in response to a request from the Animal Health Board. The review was completed in May 2007. In this report we briefly review metabolism and persistence of 1080 in living animals and then compare and contrast this with the persistence of 1080 in carcasses. We then consider the risk to non-target species and the potential for 1080 to transfer through the foodweb.

Objectives

To define:-i) the fate of 1080 in pest species ii) the risk of carcasses to dogs iii) possible exposure levels and risk of toxicity in other non-target species.

Fate of 1080 in live and dead animals including pest species

To be toxin 1080 is converted to fluorocitrate, which inhibits energy production in the tricarboxylic acid (Krebs) cycle in cells resulting in accumulation of citrate in the tissues and blood, energy deprivation, and death. Animals or humans receiving

small sub-lethal doses of 1080 show signs of poisoning, which will vary from mild to severe dependent on the dose ingested (Egeheze & Oehme 1979; Eason et al. 1997).

Absorption, metabolism, and excretion studies in laboratory and other animals since the 1950s have shown that sub-lethal amounts of 1080 are excreted both unchanged and as a range of metabolites including fluorocitrate. In laboratory rodents 1080 is rapidly absorbed and distributed through the soft tissues and organs (Hagan et al. 1950; Egeheze & Oehme 1979; Sykes et al. 1987). Defluorination of 1080 and fluorocitrate has been demonstrated in animals and other living organisms (Kirk & Goldman 1970; Smith et al. 1977; Egeheze & Oehme 1979; Soifer & Kostyniak 1983, 1984; Twigg et al. 1986; Tacle & Casida 1989).

Table 1 The elimination half-life of 1080 in plasma and muscle for possum, rabbit and mouse and brodifacoum in blood and liver for possums.

Species	Compound	Sample	Route of administration	Dose, mg kg ⁻¹	Elimination half-life (hours unless specified)
Possum	1080	Plasma	Oral	0.1	9.0 ^a
		Muscle			n.d.
Rabbit	1080	Plasma	Oral	0.1	1.1 ^c
		Muscle		0.1	0.4 ^c
Mouse	1080	Plasma	Iv injection	0.4	2.0 ^d
		Muscle		0.4	1.7 ^d
Possum	Brodifacoum	Plasma	Oral	0.1	Approx. 8 days ^e
		Liver			> 252 days ^e

n.d. = not determined

^a Eason et al. 1994b; ^b Rammell 1993; ^c Gooneratne et al. 1994; ^d Sykes et al. 1987;

^e Eason et al. 1996

The earliest reports on rats suggested that 1080 was cleared in 1–4 days (Gal et al 1961). In mice 1080 concentrations in plasma, muscle, and liver decreased by half after less than 2 hours (Sykes et al. 1987). Prompt clearance of 1080 has been confirmed for larger animals such as rabbits, goats, possums, and sheep (Eason et al 1994 a and b). The highest concentrations occur in the blood, with moderate levels in the muscle and kidneys, and the lowest concentration in the liver. All traces of the toxin are likely to be eliminated within 1 week. As illustrated in Table 1 this contrasts with the action of commonly used anticoagulant rodenticides, such as brodifacoum, which persist in the livers of animals for over 9 months (Bachman & Sullivan 1983; Eason et al 1999)

In possums that have been sub-lethally poisoned 1080 had a half-life of 9 hours, suggesting no significant amount of 1080 would be expected in the tissues of live possums 4 days after exposure (Eason et al. 1994b)

Whilst 1080 is comparatively rapidly eliminated from living possums it can persist in carcasses for many months where it will break down more slowly and will pose a risk to dogs (Meenken & Booth 1997). This phenomena has been known for many years and was studied in some detail following a possum control operation in the Wairarapa. To assess the risk of secondary poisoning carcasses were collected for up to 75 days after the control operation in June 1994. Their stomach contents were analysed for 1080 residues. Carcasses remained relatively intact during the first 39 days after death. Between 40 and 75 days decomposition was well advanced. All the possums collected contained 1080 residues. The mean concentration in the stomachs at day 25 was 30.6 mg/kg and at day 75 was 4.9 mg/kg (Meenken & Booth 1997). This study represents just one example of the degradation of 1080 in possum carcasses over winter months in the North Island of New Zealand. Undoubtedly the rate of carcasses decomposition and 1080 breakdown will be influenced by the prevailing weather conditions and could occur more quickly or more slowly in different parts of the country at different times of the year.

Risk of carcasses to dogs

Table 2 Acute oral toxicity (LD₅₀ mg/kg) for sodium fluoroacetate. N.B. These results represent a very small proportion of the LD₅₀ data available in the literature. (Rammell & Fleming 1978; Hone & Mulligan 1982; Eisler 1995)

Species	LD ₅₀ mg/kg
Dog	0.07
Rabbit	0.4
Cow	0.4
Deer	0.5
Rat	1.2
Possum	1.2

Duck	9.0
Weka	8.0

To assess the risk to dogs their relative susceptibility must be considered. Whilst fluoroacetate is a broad-spectrum toxin, there are some marked differences in susceptibility (see Table 2 above). There is an extensive database on the acute toxicity of 1080 in a diverse spectrum of species, including birds, mammals, and reptiles (Atzert 1971; Harrison 1978; Rammell & Fleming 1978; Eisler 1995). 1080 also has insecticidal properties (Negherbon 1959; Notman 1989; Booth & Wickstrom 1999). Dogs are extremely susceptible, and most other carnivores are highly sensitive to poisoning. Herbivores are less sensitive, and birds and reptiles are increasingly resistant (Atzert 1971; Rammell & Fleming 1978; Eisler 1995).

Records of dog poisoning incidents have not been maintained during all the years that 1080 has been used, however 254 dogs were reported killed by 1080 during the period 1960-76 (Rammell and Fleming 1978). The results of the persistence study by Meenken and Booth (1997) coupled with the LD₅₀ for dogs are useful for getting a better understanding of secondary poisoning risks to dogs. Based on the LD₅₀ for dogs of 0.07 mg/kg, a 20 kg dog would be seriously at risk if it consumed 200g of toxic offal containing 7 mg/kg. In this study 5 out of 6 possums on day 25 and 4 out of 10 at day 75 exceeded this threshold. One possum carcass out of six at day 25 contained 70 mg/kg, which is ten times the amount need to kill a 20 kg dog. These analyses confirm that dogs are very susceptible to secondary poisoning by 1080 and every effort must be made to keep working and pet dogs away from carcasses.

Secondary poisoning risks exist for other poisons used to control possums. Extensive contamination and poisoning of wildlife has occurred where there has been sustained use of brodifacoum (Eason & Murphy 2001). Whilst brodifacoum has a lower risk of acutely poisoning dogs the risk of secondary poisoning is probably greater for predatory and scavenging birds (especially the weka, brown skua, Australasian harrier, morepork, and southern black-backed gull) that feed on target species (Eason et al. 2002). Very high concentrations have been found in the liver of possums (Meenken et al. 1999), and the persistence of these toxic residues would be likely to parallel the persistence of 1080 in carcasses, with decomposition and slow breakdown dependent on ambient climatic conditions.

Exposure and risk to other non-target species

The risk to non-target wildlife from carcasses will depend on the likelihood of exposure, the susceptibility of different species and the pharmacokinetics of 1080 in these species. To a significant extent non-targets will be protected by their ability to detoxify 1080. Food web transfer will be limited as at each step in the food chain the amount of 1080 present will be reduced. This is in stark contrast to the biomagnification phenomenon that can occur with brodifacoum (Eason et al 1999).

In a laboratory study weta were dosed with 1080 and the persistence of 1080 residues at specified times after dosing was determined. In this experiment 1080 was eliminated from weta 6–10 days after exposure, and all weta survived dose levels of 15 mg/kg (Eason et al 1993a,b). Similar results were obtained from a native ant (Booth & Wickstrom 1999). This indicates that if invertebrates are contaminated by eating carcasses they will void 1080 over a few days and the risk of transfer of 1080 to insectivores will be limited. Field data with insects monitored in forests for 1080 residues after toxic baits were aerially sown for possum control showed that no 1080 was found in living earthworms, spiders, beetles, millipedes, or centipedes. 1080 was found in some cockroaches, bush weta, and cave weta during the period the baits were on the ground, after 3–4 weeks all invertebrate samples were free from 1080 residues (Eason et al 1993). These results are consistent with the observations that large invertebrates can eat bait (Spurr & Drew 1999) and indicates that the carcasses are less significant than baits in transferring 1080 to invertebrates and in either case this transfer process is likely to be short-lived. These field and laboratory results for invertebrates do show that 1080 is taken up by some of the terrestrial invertebrate species. Its persistence is short-lived and the risk to insectivorous birds or other predators is therefore also confined to a short period after sowing baits for possum. In conclusion there is a theoretical risk from carcasses. However the monitoring of invertebrates and birds which has shown that long-term population effects on non-target birds and invertebrate are unlikely (Spurr 1994 a and b, Spurr & Drew 1999) embraces both the effects of both primary poisoning from baits and secondary poisoning from carcasses. It is also well recognised that a number of animals are able to detect 1080 in their and either refuse to eat such food, or may reduce their consumption of food which contains 1080 (Sinclair and Bird 1984; Calver et al. 1990; Kortner et al. 2003). This may phenomenon may in part protect birds.

The risk of transfer through the food chain is far greater from second-generation anticoagulants such as brodifacoum than from first-generation anticoagulants such as warfarin, or 1080 because second-generation compounds are not substantially metabolised and excreted before death. The impacts of brodifacoum-poisoning operations on populations of non-target species have been monitored in several studies. Numbers of three indigenous bird species (western weka, Stewart Island weka, and pukeko) have been severely reduced in poison areas. For example, the entire western weka population on Tawhitinui Island was exterminated by eating baits or dead or dying rats (Taylor 1984).

Conclusions

1080 clearly has potential to cause secondary poisoning. In possums that have been sub-lethally poisoned 1080 had a half-life of 9 hours, suggesting no significant amount of 1080 would be expected in the tissues of live possums 4 days after exposure. In contrast carcasses collected from the field were shown to pose a serious risk to dogs even up to 75 days after the poisoning operation. Dogs are a special case because of their unique sensitivity to 1080. When other species such as insects or birds come into contact with 1080 in poisoned carcasses secondary poisoning does not appear to have any significant impact on populations. Sub-lethal poisoning, further biodegradation and limited transfer through the food chain

are the likely outcomes. This will be because insects and birds being less sensitive to 1080 than dogs, and in part due to the deterrent effect that any sickness resulting from eating poisoned carcasses may produce. In such cases of sub-lethal poisoning any 1080 ingested will be metabolised and excreted, and transfer through the food web will be minimal when compared to more persistent poisons used for possum control such as brodifacoum. These conclusions are in keeping with the analyses of Innes and Barker (1999) who suggested that the ecological costs of using 1080 is far less than the damage costs if it is not used, due to the magnitude of the effects of possums. They further conclude that this may not be the case when persistent poisons such as brodifacoum are used.

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