# 1080 and Wildlife: Scientific and ethical issues raised by its use on Australian mammals

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**ABSTRACT**

Sodium monofluoroacetate (Compound 1080) is used to kill pest species such as foxes in Australia and possums in New Zealand. In both countries it is an essential component of conservation programmes. The poisoned animals die in considerable pain. Striking a balance between its effectiveness as a conservation tool and the animal welfare issues involved has proved to be difficult. This review examines the arguments on either side. It also raises the question of how long selection for resistance will take to develop. The presence of resistant vertebrates in Western Australia is ascribed to the selective effect of poisoned plants whose seeds and flowers contain 1080. Western vertebrate subspecies have evolved resistance which is not present in estern subspecies and so resistance can evolve within the lifetime of a species.

Key words: selection for resistance, Gastrolobium, conservation, animal welfare, compound 1080, sodium monofluoroacetate

## Introduction

1080 is the common name for sodium monofluoroacetate. It is one of the most powerful known poisons in the world - it kills many animal taxa upon ingestion of only a few milligrams and is particularly potent against canids (dogs and foxes). It enters the mitochondria where it inhibits enzymes involved in the tricarboxylic acid cycle which produces energy under aerobic conditions. The use of 1080 in Australia and New Zealand for pest management raises ethical and scientific issues (Weaver 2003) which are the subject of this short review.

## The issues

The great advantage of 1080, from the point of view of agricultural and wildlife management authorities, is that it is highly efficacious, economical and can be delivered by baits (Arkle 2002). It is degraded through bacterial actions, and usually does not persist in the environment (Eason *et al.* 1992, 1994b; Livingstone & Nelson 1994; Booth *et al.* 1999). With the exception of dogs, it is not often involved in any form of secondary poisoning (Eason *et al.* 1994a). However, the affected animals expire over an extended time (hours), and are in considerable pain during at least some of that period.

The use of 1080 has become a contentious issue. In New Zealand, the Royal Society for Prevention of Cruelty to Animals has issued a report entitled "The use of 1080 for Pest Control" (Boyd 2004) which gives an account of its effect upon a variety of animals. Dogs, foxes and other canids are especially affected, and die in obvious pain over a period of hours (Goh *et al.* 2005). The great variation in symptoms between species have been divided into four categories: Class I where the main effects are upon the heart, Class II where both heart and central nervous system are involved, Class III where the main effect is upon the central nervous system and Class IV where the response is "atypical". This classification has however been disputed (Sherley 2004).

In Australia, 1080 has been the subject of a parliamentary enquiry (Hansard 2005). The submissions to this make it clear that community opinion is much divided.

One main reason that 1080 is of considerable interest to Australians, is that resistance to its effects has evolved in Western Australian animals, because plants in that region accumulate 1080 in their seeds and in their flowers, ie in their reproductive material (McIlroy 1981; Mead *et al.* 1985; Twigg *et al.* 1991; Twigg and King 1991, Twigg *et al.* 1996; Twigg *et al.* 2003). The accumulation of 1080 in plants is obviously an evolution of defence against over-browsing in Western Australia (Oliver *et al.* 1977). This is particularly true in the plants in south-western Western Australia, and the result is that most of the mammal, bird and reptile species in this region are able to consume quite large quantities of it without being affected.

This evolution has clearly occurred within the lifetime of a number of different taxa. This is true because the many eastern forms of a species are often very sensitive to the substance, whereas the western forms are very resistant. The most dramatic example is that of the common brushtail possum *Trichosurus vulpecula*, which in Western Australia is 150 times more resistant to the effect of 1080 than is the eastern Australian form (Twigg and King 1991).

Serendipity favoured New Zealand when brushtail possums from eastern Australia, rather than the western form, were introduced to that country - otherwise use of 1080 there would not be an effective tool for pest management. In light of these issues, it is also pertinent to ask if 1080 resistance is evolving in New Zealand possums?

This evolution can occur fairly quickly. In Western Australia, the use of 1080 has taken place over a period of some 30 or 40 years for control of populations of European rabbit *Oryctolagus cuniculus*. The work of Laurie Twigg and his colleagues in this region has provided clear evidence that resistance has developed within rabbits in control areas (Twigg *et al.* 2002).

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The issues arising from the use of 1080 are therefore these:

Is it ethical to cause pain in one animal species to conserve another?

Will evolution for resistance occur which causes 1080 to become an in-effective tool for managing pests and over-abundant populations?

How can these issues be scientifically and ethically resolved?

## Discussion

Let us first consider the issue of 1080 resistance evolving in New Zealand possums. This could occur due to physiological resistance or behavioural avoidance of the baits which are delivered in carrots marked green. Given what is known about the evolution of resistance in general, and that 1080 has been used in New Zealand for about a half a century, it is quite likely that resistance has actually begun to evolve in some of the possums in New Zealand.

It is also relevant to ask of wildlife management authorities in both Australia and New Zealand: What is the predictable time frame for the evolution of resistance in other target species?

In Australia at present 1080 is undoubtedly a very effective management tool for both biological conservation and pest control. The success of its use to control foxes *Vulpes vulpes*, particularly in Western Australia, is now well documented (Possingham *et al.* 2003). It has been shown in very large scale and rigorous experiments that Western Shield, which is the name given to the use of 1080 to control foxes in Western Australia, has resulted in an increase in the abundance and diversity of species, which were, until recently, considered to be endangered. In one instance, the program resulted in the re-emergence of the Gilbert's potoroo *Potorous gilbertii*, a species previously considered extinct (Sinclair *et al.* 1996).

The success of Western Shield is one factor which causes people in the eastern part of Australia to accept the use of 1080 to control foxes. At the same time, most people are aware that it kills in a manner which causes the poisoned animal to die in some pain.

The scenario above (pain for individual animals vs recovery of a threatened native species) has led to the curious situation where in mainland Australia we do socially accept the use of 1080 but in Tasmania and New Zealand the reverse trend is observed. Until the recent introduction of foxes into Tasmania these were the only two parts of Australasia where foxes were not a conservation issue. The realisation that foxes cause such terrible damage to our native fauna appears to have allowed people to accept its use to achieve a conservation outcome.

Ten years ago, scientists postulated that we had only about a decade remaining before the use of 1080 as a management tool would be banned due to social pressure. It seemed imperative that we find some other control methods in order to be able to control populations. But that particular speculation has turned out to be incorrect. The general population in Australia still accepts 1080 as an acceptable tool for managing pest animals.

On mainland Australia, the target species are foxes, rabbits, wild dogs and feral pigs *Sus scrofa*. All are introduced species, with known economic, environmental and human health risks. Consequently, the use of 1080 is supported through lack of empathy and despite real or perceived risks to native taxa.

In Tasmania, the primary targets are endemic wallabies and brushtail possums which damage saplings and reduce regeneration success in forestry operations. Forestry in general, and in Tasmania in particular, is controversial within the environmental community and the population at large. The desired effect of the control operation is to increase forest health and growth rate, and is therefore only economic, whilst the poisoning operations target charismatic native fauna. There is consequently a strong objection in Tasmania to its use and the ethics issue there is a very live one indeed. The resolution of this particular debate has been that the Tasmanian government has passed legislation to prohibit the general use of 1080. Forestry Tasmania, the government land management authority affected, has accepted that this practice is not available as a tool for forest management.

## Scientific progress

Considering the points and results above, we put forward that the main scientific and management issue is this: How long will resistance take to evolve in possums and foxes? It could well be that only decades remain before 1080 becomes ineffective for these taxa. To guide our judgement of the applicable time frame, we can refer to the large amount of information available concerning the appearance of resistance, particularly chemicals used against insects or the gut worms of ruminants (Mc Kenzie 2000). These results show that under very strong selection - and the use of 1080 is very strong selection - there is a rapid emergence of resistance.

The resistance which emerges under such strong selection pressure is often mono-factorial, especially when it is on phenotypes outside the normal range of the species. That is, only one gene may be involved. In contrast, longer term selection gives a slighter selection pressure over extended periods of time, resulting in the emergence of multi-factorial genetic resistance (more than one gene is involved). This is especially so when the selection is on phenotypes within the normal range of the species (McKenzie 2000).

One of the most puzzling features of 1080 resistance is that, in those animals where it has undoubtedly been selected for in the past, even when there is no 1080 in the environment for a long period of time thereafter, 1080 resistance is maintained. It seems that, in the case of 1080, the genes are maintained even in the absence of selective pressure.

Another puzzle is: Why don't the plants poison themselves? This is a question which could be addressed experimentally in order to see what might be the basis for the resistance in the animals in Western Australia.

This information may be useful to provide a solution to extend the useful time frame for 1080 control. For instance, the occasional introduction of non-resistant genetic material could reduce resistance in the general population of the target species.

To provide real options for management, other and varied scientific issues remain to be settled. One of these is addressed by a program at the University of New South Wales, supported by the Australian Research Council, to determine the genetic basis of resistance to 1080 which occurs in tammar wallabies *Macropus eugenii* and in possums. Our procedure involves crossing and then back crossing the tammars from the two parts of Australia. The eastern tammars are far more susceptible to 1080 than their Western Australian conspecifics.

## Ethical responsibilities

The ethical issues are ones upon which there is no agreement across the community. Clearly, the main ethical issue is this: Should introduced species die painful deaths to protect native species, economic interests and the environment?

It is not possible to resolve ethical issues to the satisfaction of everyone. However, we can address concerns and provide adequate reasoning and information for wildlife management actions.

We could look at the ethics of the issue as a matter of responsibility. It could be said that we, the humans, who introduced foxes into Australia, are responsible for the problem. Foxes were introduced primarily so the privileged few could enjoy the great pleasure of fox hunting. This seems ridiculous by today's social values, and was not universally accepted when the introduction occurred. At the time, Oscar Wilde said about fox hunting, "It's the pursuit by the unspeakable of the inedible". Although the skills of horsemanship, dog training and knowledge of the countryside were once important, the formal hunt now appears as one of the most bizarre forms of entertainment anywhere in the world. Social custom and history notwithstanding, allocating blame in the past does not resolve ethical issues in the present.

Another relevant approach to ethical issues is to consider the null alternative, which is: What would be the consequences of not using 1080 [to control foxes, for example]?

In environmental terms, the consequences are that the resurgence of many of the small mammals now occurring in Western Australia and elsewhere would cease or slow down. In ethical terms, with regard to individual animals, all of the prey animals of the target species (e.g. those eaten by foxes) would die painful deaths, albeit probably quicker than death by 1080. However, each fox would account for many deaths and much pain.

Another path to resolution is to consider a new situation, as presented by the introduction of foxes to Tasmania. At present, it is not apparent whether or not the fox will become established. Without doubt, the use of 1080 would be one of the most effective control tools if this were to be the case. Clearly, if foxes were to be established in Tasmania, many Tasmanian small mammals and other critical weight range taxa would be in serious trouble. Would it be ethical not to use 1080 in this case? Posing this question seems to provide an answer to the geneticist, ecologist and wildlife manager, at least.

Finally, we must consider whether there are alternatives to 1080 that will be effective at the same level of expense and control results with no increase in animal suffering or human health risk. The answer is: there might be some effective alternative poisons, but they are more expensive, and they would be open to very similar objections to those currently directed at the use of 1080.

Given that there is no feasible alternative, the responsible ethical approach is to ask: Could 1080 baiting programs be improved by more humane approaches to application and technology? One current suggestion is that the addition of an anaesthetic to the bait would reduce suffering by rendering the target animals unconscious before they succumb to the effects of 1080. This suggestion has serious support, but its adoption and use will no doubt depend on technical feasibility and economic factors.

In conclusion, alternatives and improvements to 1080 control techniques need to be vigorously pursued for clear scientific, social and environmental reasons. Economics, as the controlling factor for application, will determine the availability and application of any innovations developed.

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## References

**Arkle, P. 2002**. Submission to the National Registration Authority on the Review of Sodium Monofluoroacetate (1080) by the National Farmers' Federation: Canberra.

**Booth, L.H., Ogilvie, S.C., Wright, G.R. and Eason, C.T. 1999.** Degradation of sodium monofluoroacetate (1080) and fluorocitrate in water. *Bulletin of Environmental and Contamination Toxicology* **62(1)**: 34-9.

**Boyd, J. 2004.** *On the Use of 1080 for Pest Control* Submission to the Animal Health Board and Department of Conservation by the Royal New Zealand Society for the Prevention of Cruelty to Animals: Wellington.

**Eason, C.T., Wright, G.R. and Fitzgerald, H. 1992.** Sodium monofluoroacetate (1080) water residue analysis after large-scale possum control. *New Zealand Journal of Ecology* **16**: 47-49.

**Eason, C.T.R., Gooneratne, R., Fitzgerald, H., Wright, G. R. and Frampton, C. 1994a.** Persistence of sodium monofluoroacetate in livestock animals and risk to humans. *Human Experimental Toxicology* **13**: 119-122.

**Eason, C.T., Morgan, A.J. and Wright, G.R. 1994b.** The fate of sodium monofluoroacetate (1080) in stream water, and the risk to humans. *Human Experimental Toxicology* **13**: 640-640.

**Goh, C.S., Hodgson, D.R., Fearnside, S.M., Heller, J. and Malikides, N. 2005.** Sodium monofluoroacetate (Compound 1080) poisoning in dogs *Australian Veterinary Journal* **83(8)**: 474-479.

**Hansard 2005.** Standing Committee on Agriculture, Fisheries and Forestry: Impact on agriculture of pest animals. Commonwealth of Australia, Canberra, 16 March 2005.

**Livingstone, P.G. and Nelson, P.C. 1994**. *Possum Control and the Use of 1080 in New Zealand.* New Zealand Animal Health Board. ISBN 0-477-01694-4.

**McIlroy, J.C. 1981.** The sensitivity of Australian animals to 1080 poison II. Marsupial and eutherian carnivores. *Australian Wildlife Research* **6**: 385-399.

**McKenzie, J.A. 2000.** The character or the variation: the genetic analysis of the insecticide-resistance phenotype. *Bulletin of Entomological Research* **90(1):** 3-7.

**Mead, R.J., Oliver, A.J., King, D.R. and Hubach, P.H. 1985.** The co-evolutionary role of fluoroacetate in plant-animal interactions in Australia. *Oikos* **44**: 55-60.

**Oliver, A.J., King, D.R. and Mead, R.J. 1977.** The evolution of resistance to fluoroacetate intoxication in mammals. *Search* **8**: 130-132.

**Possingham, H., Jarman, P. and Kearns, A. 2003.** The Western Shield fauna recovery program for Western Australia. *Conservation Science Western Australia* **5(2)**: 2-18**.**

**Sherley, M. 2004.** The traditional categories of fluoroacetate poisoning signs and symptoms belie substantial underlying similarities. *Toxicology Letters* **151(3)**: 399-406.

**Sinclair, E.A., Danks, A. and Wayne, A.F. 1996.** Rediscovery of Gilbert's Potoroo, Potorous tridactylus. *Western Australia Australian Mammalogy* **19**: 69-72.

**Twigg, L.E. and King, D. R. 1989.** Tolerance to Sodium Monofluoroacetate in Some Australian Birds. *Australian Wildlife Research* **16**: 49-62.

**Twigg, L.E. and King, D.R. 1991.** The impact of fluoroacetate-bearing vegetation on native Australian fauna: a review. *Oikos* **61**: 412-430.

**Twigg, L.E., King, D.R., Bowen, L.H., Wright, G.R. and Eason, C.T. 1996.** The fluoroacetate content of some species of the toxic Australian plant genus, *Gastrolobium*, and its environmental persistence. *Natural Toxins* **4**: 122-127.

**Twigg, L.E., Martin G.R. and Lowe, T.J. 2002.** Evidence of pesticide resistance in medium-sized mammalian pests: a case study with 1080 poison and Australian rabbits. *Journal of Applied Ecology* **39**: 549-560.

**Twigg, L.E., Martin, G.R., Eastman, A.F., King, D.R. and Kirkpatrick, W.E. 2003.** Sensitivity of some Australian animals to sodium fluoroacetate (1080): additional species and populations, and some ecological considerations. *Australian Journal of Zoology* **51**: 515-531.

**Weaver, S. 2003.** Policy Implications of 1080 Toxicology in New Zealand. *Journal of Remote Environmental Health* **2**: 46-49.