The 1080 Plant

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At the moment, there is a lot of interest and a fiery debate about the use of 1080 in controlling possums. Interestingly, there are environmentalists on both sides of the debate. The 'antis' argue that 1080 poisons our environment, while the 'pros' argue that its use greatly reduces possum damage, and allows recovery of our native vegetation from the drastic effects of introduced animals. Unfortunately, the debate is being muddied by claims that are not based on any concrete evidence or even contradicted by well-established knowledge. Perhaps the biggest confusion relates to the nature and use of the bait (the stuff the poison is carried in) versus the nature of the poison itself. Many of the concerns about use of 1080 are essentially about the form of the bait and the way that the bait is distributed, so that other poisons used in the same ways would present the same problems. Largely neglected in the public debate is the nature of the poison itself, particularly in relation to its status as a natural plant product, rather than being some unnatural creation of unethical chemists.

To the biochemist, 1080 is an intriguing compound. To start with, it is very simple, with only 2 carbon atoms out of a total of 8 atoms in the molecule. (In comparison, a simple sugar like sucrose has 12 carbons and 45 atoms). Thus it can easily pass into living cells. All organisms take in a host of different small molecules. The enzymes in the cell chop, change and join together these small molecules until they become part of the structural and metabolic machinery crucial to living organisms. Enzymes act in a defined series of steps. An enzyme recognises its substrate, modifies it, and passes it on to be the substrate of the next enzymatic step. 1080 is the codename for fluoroacetate, which is acetic acid (the material of vinegar) that has had one of its hydrogen atoms replaced by a fluorine. Acetic acid is an absolutely key small molecule in the series of steps by which all living things "burn" carbohydrate to carbon dioxide, water and energy. At one of the steps down the line, acetic acid will eventually become citrate (the acid of lemons). It seems that the main way in which 1080 acts is by fooling the first few enzymes of the cycle into thinking it is genuine acetate. Thus it is processed biochemically until it reaches the stage where it becomes fluorocitrate Unfortunately at that point, the enzyme (aconitase) that usually processes citrate does not handle fluorocitrate, which jams the enzyme so the system is blocked. Energy production drops and citrate piles up, in turn interfering with other processes. This is such a crucial effect on the metabolism that an organism with such a blocked system can rapidly die. The process is like using a damaged key in a lock. It can be inserted and turned part way round, but not only is it unable to open the lock, but the lock becomes jammed so the correct key is unable to be used. Because all living things use this same biochemical path, all plants and animals can potentially be poisoned by 1080 in this way. The very different levels of resistance that occur can come about in several ways: the enzyme that starts off with the acetate can refuse to touch the 1080, or the particular aconitase can be unaffected by the fluorocitrate, or the cells can refuse to let the 1080 in, or they can break it down into harmless products before it can get into the acetate pathway.

Enzymes that break down the 1080 are very widespread, being produced by many soil fungi, many bacteria, and even by the tissues of the animal being poisoned. A possum which has taken in 1080, but insufficient to kill it gets rid of almost all the 1080 in its body within a day - about 30% is excreted, and the rest is broken down to simple fluoride or converted into organic fluorides that are no longer toxic. In the soil and ground water, 1080 is mainly hydrolysed into fluoride and glycolic acid, both normal materials in the environment. There is little accumulation in nature because it is broken down at many levels in the food chain. One exception however is the dead body of the poisoned possum - there the 1080 and its toxic derivative fluoroacetate can hang around for up to a month, until the body decays sufficiently for the soil bacteria and fungi to have a go. It is this dead body that gives rise to much of the "by-kill" or secondary poisoning, in which non-target animals eat some of its poisoned flesh. The dog is particularly at risk here, both because it is the most likely to scavenge, and because it is about 10 times as sensitive to the poison as a possum, in terms of the milligrams of 1080 per kilogram of body weight required to cause death. In comparison, humans are about half, birds a quarter, and reptiles a hundredth as sensitive. Because of our lower sensitivity and higher body weight, the amount that is toxic for a human is about 50 times that needed to kill a possum. Although there is potential for birds and insects living in the treated areas to be killed, the most careful studies show the kill is very low, to a level where "1080 poisoning is not an additional cause of mortality but simply replaces other causes of mortality such as predation and winter starvation" (Spurr, 1994, p. 130). In areas like Pukeiti Forest, the net effect of removing most of the possums has been an increase in bird life, not surprising when you learn that possums are partial to snacks of bird eggs to go with their vegetable diet.

Does it really matter that we have possums in our forests? Too right, and particularly for those concerned for conservation of the New Zealand flora. There are about 70 million possums in New Zealand, eating about 14 million tons of vegetation a year. That's over 2 tonnes per hectare of forest, and about 10% of what all our 50 million sheep eat - but then there is over 2 times as much pasture as forest. In other words, possums are grazing our forests about a quarter as intensively as sheep graze our fields. Native vegetation, evolved in the absence of grazing animals, just can't withstand that sort of pressure. But wait, there's more. Possums are the major reservoir of bovine tuberculosis, a disease that is highly debilitating to our cows and deer, and which also infects humans. It's a measure of the health and commercial impact of bovine Tb that MAF currently spends over $5 million per year in possum control, but estimates the direct impact on our farming costs to be $80-100 million a year. The challenge is to not only reduce the possum populations, but to do so before the health problem extends beyond the 25% of the country where bovine Tb is now present. And reducing possum numbers does work. In parklands where an effective poisoning or trapping campaign has been carried out, there have invariably been rapid and easily-visible improvements in the vigour of the trees. We can see this for ourselves on Rangitoto and in the Auckland Regional Council parks. In the Waitakeres this year, I saw rata flowering for the first time in a couple of decades, while bird lovers tell us of the big increases in bird life (particularly kereru) in places like Wenderholm.

To those interested in plants, the most fascinating thing about 1080 is that it is a natural product (most likely evolved as a defence mechanism against grazing animals) produced by a number of plant species in at least 5 genera within two different plant families, growing widely in two different continents. In South Africa, species of 'gifblaar' or 'poison leaf' (*Dichapetalum*; family Dichapetalaceae) were known to be highly poisonous to stock for a century before their poison was identified. The same was true of Western Australian plants like 'box poison' (*Gastrolobium parviflorum*) and 'heart-leaf poison' (*G. bilobum*) (both family Leguminosae: Papilionoideae) and *Acacia georginae* (family Leguminosae: Mimosoideae). In the 1940s chemists twigged that these plants contained heaps of fluoroacetate - that is, 1080. More recently 'cafezinho' or 'erva-de-rato' (*Palicourea marcgravii*; family Rubiaceae) in South America has been found to owe its poisonous properties to the presence of the 1080 toxin. Some areas of southwestern Australia produce much more 1080 per hectare than is used for poison drops in our country. To give you an idea just how much these plants produce, concentrations over 2g/kg dry leaf have been found - meaning that just 4kg of leaf would be enough to provide baits for treating 1 hectare of forest, and 2-3g (the amount of tea in a tea-bag) has as much 1080 as a standard bait used in air drops, easily enough to kill a possum. For those who believe in using only organic products in our horticulture, *Gastrolobium parviflorum* extract should be a highly acceptable material for possum control! A much wider range of plants, including soybeans and tea, produce low concentrations of 1080 under some circumstances, mainly when growing on fluoride-rich soils. Some types of tea are produced on fluoride-rich soils, so for some New Zealanders, the highest concentration of 1080 they are exposed to is in their daily cuppa. What all that means is that in using 1080 we are not putting a new poison into the environment, we are increasing the range and level of what is a natural occurrence. Thus the risks of putting synthetic 1080 into the environment have to be read in that light.

A poison leaf (Dichapetalum cymosum)

Heart-leaf poison
(Gastrolobium bilobum)

Reference

Spurr EB (1994). Review of the impacts on non-target species of sodium monofluoroacetate (1080) in baits used for brushtail possum control in New Zealand. *Proceedings of the Science Workshop on 1080*, pp124-133. Royal Society of New Zealand, Miscellaneous Series 28.

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