

## Fluoroacetate-bearing vegetation: can it reduce the impact of exotic mammals on wildlife conservation?

THERE is no doubt that fluoroacetate-bearing vegetation (also known as poison peas) has had a profound effect on the evolution and persistence of Western Australian biota. Most of these plants belong to the genus *Gastrolobium*, and most are found in the south-west corner of Western Australia (Gardner and Bennetts 1956; Aplin 1971; Twigg and King 1991). The toxic principle of these plants, fluoroacetate, is also manufactured synthetically as 1080 (sodium fluoroacetate) for Australia-wide control of vertebrate pests, such as rabbits *Oryctolagus cuniculus*, foxes *Vulpes vulpes*, wild dogs *Canis lupus familiaris* and feral Pigs *Sus scrofa* (Twigg and King 1991). Because of their co-evolution with fluoroacetate-bearing vegetation, many native animals in Western Australia have developed varying levels of tolerance to this highly toxic compound. In contrast, introduced mammals are generally highly sensitive to fluoroacetate. Although it is not a prerequisite for safe and effective pest control programmes with 1080, the toxicity differential between native and introduced animals provides an additional "safety net" when using 1080 products in Western Australia.

The importance of under-storey vegetation to the persistence of many indigenous Western Australian mammals is well recognized (e.g. Christensen 1980; Short *et al.* 1992; Sinclair and Morris 1995; Short *et al.* 2005). This can include a range of habitats, with and without fluoroacetate-bearing vegetation, and a range of under-storey densities. However, it is particularly true of the mesic areas in south-western Western Australia where fluoroacetate-bearing plants are common. For example, Short *et al.* (2005) argued that the presence of current-day thickets of fluoroacetate-

bearing plants, such as Heart-leaf Poison *G. bilobum*, has provided important refugia for native mammals from exotic predators (e.g., foxes, feral Cats *Felis catus*). They also suggested that: 1) these toxic plants help to reduce predator numbers by secondary poisoning, 2) the natural presence of fluoroacetate in these areas is important to the long-term persistence of many native animals, and 3) the provision of toxic *Gastrolobium* seed to native animals would help to reduce predation by exotic predators (see below), and this should be considered in future conservation management strategies.

However, there is another equally plausible explanation for the suggestion that these poison-plant thickets are very important to wildlife conservation. Such thickets may simply be a pseudo-measure of habitat quality. Consequently, they may not provide a direct causal mechanism between the presence of fluoroacetate and the persistence of native fauna. Virtually all species of the toxic plants have been implicated in livestock deaths in the past, and these plants seriously impeded the development of agricultural enterprises in Western Australia (Gardner and Bennetts 1956; Aplin 1971). Consequently, where dense stands occurred, these areas were often left as "conservation reserves" that remained relatively undisturbed by agricultural activities. Although they may have been affected by changing fire regimes, and by fertilizer run-off, many of these areas have retained their basic overall vegetation structure. Thus, predator-protection may result from the density or otherwise of the under-storey vegetation cover, which can include fluoroacetate-bearing plants, rather than the presence of fluoroacetate *per se*. The two explanations are not

mutually exclusive but, together, they provide a more detailed explanation as to why the persistence of native fauna is often linked to under-storey vegetation density in this complex ecosystem.

Short *et al.* (2005) also suggested that the management of exotic predators, particularly feral Cats, could be improved by creating "toxic wildlife" which would be lethal to such predators. They proposed this could be achieved by harvesting the seed of highly toxic fluoroacetate-bearing species, and providing this in feeders for reintroduced native animals so that they ingested sub-lethal amounts of fluoroacetate thereby becoming lethal to exotic predators. However, this idea, which has been suggested previously (e.g., P. Christensen pers. comm.), is fraught with danger as it over simplifies the sensitivity and metabolism of fluoroacetate in indigenous wildlife. While it is true that many Western Australian native animals have developed a tolerance to fluoroacetate, the degree that this occurs depends upon the level of exposure and the need to consume food containing fluoroacetate for each species (Twigg and King 1991). For example, at present, the toxic plants can only comprise around 27% of the diet of Western Grey Kangaroos *Macropus fuliginosus* (Mead *et al.* 1985). That is, there is a biological arms race between these plants and our native animals. However, it is important to recognize that the tolerant Western Australian species can still be killed with fluoroacetate, they just need to consume more than their unadapted counterparts. Thus, deliberately feeding the highly toxic seed concentrated at feeding stations is likely to result in the death of some native species before the stop-feed action of fluoroacetate is initiated (it generally takes around

1 hour or more for the signs of fluoroacetate poisoning to manifest — Twigg and King 1991). This would be particularly so for those individuals yet to attain adult weight. That is, delivering the “correct dose” would be nigh on impossible in natural environments. Furthermore, most fluoroacetate (1080) is excreted or eliminated from mammals within 24 hours of ingestion (Twigg and King 1991), and so the “toxic wildlife” would need to regularly ingest food with fluoroacetate if they were to remain lethal to exotic predators. The ingestion of sub-lethal amounts of fluoroacetate from “toxic wildlife” by exotic predators is also likely to increase the selection for increased tolerance to fluoroacetate (1080) in these predators. In addition, it would not be possible to collect sufficient plant material, including seed, for this to be a practical option, and such collections are unlikely to be conducive to the conservation of *Gastrolobiums*.

It also needs to be recognized that relatively low levels of fluoroacetate can affect the breeding performance of reptiles, birds and mammals, but this effect is reversible, and does not persist once the exposure ceases (Twigg and King 1991). It has also been argued that the selection pressure for tolerance to fluoroacetate may well be acting primarily through the chronic effects of fluoroacetate, such as depletion of glutathione, calcium and some neurotransmitters (Twigg and King 1991; Twigg and Parker 2010), and the fertility effect, rather than simply through the acute (lethal) effects of fluoroacetate. Thus, deliberately exposing native wildlife to excessive amounts of fluoroacetate is not as simple as it seems.

It is difficult to assess the merits of the suggestion that “improved predator management at fauna recovery sites would be facilitated through the greater use of under-storey plantings of *Gastrolobium* as a buffer around key fauna recovery sites” (Short *et al.* 2005). In native species, fluoroacetate-tolerance occurs

in most stages of the food chain and includes micro-organisms (some fungi and bacteria can degrade fluoroacetate), insects, reptiles, mammals and birds. It also includes herbivores, omnivores, carnivores and decomposers (Twigg and King 1991). However, relating this evolutionary exposure to short-term benefits re control of exotic predators via secondary poisoning from animals eating the toxic plants is problematic. Secondary poisoning is known to occur during 1080-baiting programs, but mainly where poison-bait is concentrated in specific areas (e.g., 1080-bait trails and poisoned rabbits killing foxes — Algar and Kinnear 1996). There have also been occasional reports of native birds and macropods killing domestic cats and dogs when they had fed on apparently toxic carcasses (Serventy 1966; Peacock *et al.* 2011). However, these events appear to be relatively uncommon, and have mainly occurred during spring when fluoroacetate-bearing vegetation is setting seed. With current knowledge, it is not possible to state that “toxic wildlife” would result in the death of invading exotic predators as suggested by Short *et al.* (2005). Furthermore, would the frequency of such events be sufficient to have an overall impact on predator populations (e.g., cats, foxes)? The use of “toxic wildlife” at fauna recovery sites would also be an unusual and potentially risky approach as it relies on the predation of protected species that already have low abundances.

While having some merit for conserving *Gastrolobiums* (see below), the suggestion that fluoroacetate-bearing plants should be planted and/or encouraged to improve the conservation of indigenous Western Australian fauna also assumes that fluoroacetate is uniformly distributed throughout the environment, and within plants. This is not the case as there can be considerable variation between plants of the same species, between plant parts, and within individual stands of a given species (Aplin 1971; Twigg *et al.* 1996).

These levels can also vary between seasons. Thus, it would not be possible to realistically manage the level of naturally-occurring fluoroacetate. This is not to say that such plantings would not provide physical protection from predation. It also appears that some plant species may employ higher concentrations of toxic secondary compounds in areas that herbivores consider safe, such as dense under-storey, to protect the plants from over-grazing (Nersesian *et al.* 2011). If this actually occurs with fluoroacetate-bearing vegetation, then it may negate some of the advantage of the shelter provided by such under-storey, and also favour the development of higher levels of fluoroacetate-tolerance.

There are two main ways to test the hypothesis that fluoroacetate-bearing vegetation reduces the predation of native animals through secondary poisoning of exotic predators. Firstly, fluoroacetate levels within key tissues such as liver and muscle could be determined in free-ranging native animals in the size-range most predated by exotic predators. These levels could then be used to estimate whether residual fluoroacetate would be sufficient to kill adult exotic predators. Secondly, the survival of native animals, and the abundance of predators, could be compared in the presence of *Gastrolobium* thickets with 1080-baiting for fox control, in thickets without 1080-baiting, and in areas without fluoroacetate-bearing plants or 1080-baiting. Both options would be difficult and costly to implement, particularly measuring fluoroacetate levels in free-ranging animals. While 1080 tissue residues have been measured in the carcasses of some target species (e.g., rabbits — Twigg *et al.* 2003, feral Pigs — Twigg *et al.* 2005), these residues generally decline to relatively low levels within 2–3 days of death. Carcasses also often totally decompose within 3–6 days. Liver is a key tissue for measuring fluoroacetate residues and whether this could be done successfully by biopsy from live animals is unknown. Further, it

would be rather hit and miss with free-ranging animals as it would not be known if and when they had ingested naturally-occurring fluoroacetate. Consequently, large sample sizes would be required in order to obtain sufficient data to determine whether fluoroacetate was, or was not present. Artificial feeding stations with toxic seed could be used to improve capture and sampling rates for herbivorous/omnivorous species, but this is unlikely to reflect natural ecosystem responses. Obviously, it would not be acceptable to kill large numbers of native animals to obtain tissue samples.

Establishing any direct impact of poison peas on rabbit abundance is also problematical. Interestingly, many of the rabbit-problem areas in south-western Western Australia occur in areas with abundant fluoroacetate-bearing vegetation. Nevertheless, there have been occasional anecdotal suggestions that rabbit numbers may be lower in some areas with these plants (Griffiths and Boase 2009). However, the sensitivity to fluoroacetate of Western Australian rabbits with and without past exposure to fluoroacetate-bearing plants has been tested and does not appear to differ between these two habitat types (Wheeler and Hart 1979). Rabbits are generally grazers, rather than browsers (Martin *et al.* 2007), and are therefore unlikely to consistently consume mature poison plants. They may, however, potentially feed on seedlings of these plants (which can be highly toxic), but their main impact is often on herbaceous and forbaceous species (Martin *et al.* 2007). Fluoroacetate occurs in all major plant tissues, including wood (Twigg *et al.* 1996). Rabbits tend not to penetrate forested areas to the same extent that they occupy agricultural lands. This suggests that under-storey vegetation density, irrespective of whether fluoroacetate-bearing plants are present, is important in determining the distribution of rabbits. Further field-research is obviously required to resolve this conundrum.

Ensuring that the health of our remaining bush remnants continues or indeed, is improved, by encouraging a diverse and dense under-storey, including the presence of fluoroacetate-bearing vegetation, as suggested by Short *et al.* (2005), makes sound ecological sense. This is particularly so with fluoroacetate-bearing vegetation as at least 10 species of *Gastrolobium* are rare or threatened, and are on the Department of Environment and Conservation's Declared Rare and Priority Flora List (Government Gazette, WA, 17 August 2010, pg. 4039). This outcome has resulted from past, deliberate persecution, and from the degradation of key habitats (e.g. roadside verges). Despite their benefits to Western Australian ecosystems, the poison peas have not always been seen in favourable light. Contrary to popular belief, virtually all species of *Gastrolobium*, at some time of their life cycle (e.g. young shoots, apical meristems, seed - Aplin 1971; Twigg *et al.* 1996), have the potential to kill domestic livestock. Thus, convincing farmers that they should retain those species of *Gastrolobium* which rely more on physical deterrents rather than high levels of fluoroacetate to reduce herbivory, as suggested by Short *et al.* (2005), would be a difficult task.

I do not disagree with the supposition that retaining viable stands of native bush, including those with fluoroacetate-bearing plants, provides important conservation benefits to Western Australian flora and fauna. Nor do I dispute the detrimental impacts that exotic birds and mammals can have on native wildlife. However, with our current knowledge, it is not possible to always make definitive statements about how areas with fluoroacetate-bearing vegetation function, or by what casual mechanisms they operate. Like many others, and as I know Short *et al.* (2005) appreciate, I also acknowledge that these ecosystems are complex and not yet well understood, particularly the structural role of fluoroacetate-bearing vegetation in mesic environments. However, with the limited

resources available, we need to ensure that conservation efforts are invested wisely, and in areas likely to provide the maximum short- and long-term benefits. For example, we need to ensure that vertebrate pest control programmes are conducted properly, habitat fragmentation and degradation are minimized, and fire regimes are appropriate. We now know that many Western Australian rabbit populations are becoming less susceptible to 1080-baiting (Twigg *et al.* 2002), and there is strong anecdotal evidence that some fox and wild dog populations are no longer well controlled with 1080 products. Given the considerable importance of 1080-baiting programs to agricultural production and wildlife conservation in Australia, these findings have quite serious implications, and need to be addressed.

#### ACKNOWLEDGEMENTS

Thanks to Mike Calver and Graham Fulton for their helpful comments on improving earlier drafts.

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