SODIUM FLUOROACETATE RESIDUE IN FERAL PIG (*SUS SCROFA*) CARCASSES – IS IT A SIGNIFICANT SECONDARY POISONING HAZARD?

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ABSTRACT

Feral pig control in Australia is heavily reliant upon poisoning with sodium fluoroacetate (1080) bait. Tissue residue levels may be considerable and pose a potential risk to non-target consumers. Tissue/fluid samples (liver, kidney, stomach, stomach contents, small intestine, large intestine, muscle and eye) from lethally poisoned feral pigs were removed and assayed for fluoroacetate concentration. The digestive system, specifically the stomach contents and stomach, consistently contained the greatest concentration of 1080 within individuals. Few non-target animals apart from introduced mammals (fox, dog, cat) appear at risk from consuming muscle tissue, however, many native species may be at risk from consuming visceral tissue (especially stomach and contents). The practical risk is probably low and reduced given the rapid decomposition of carcasses in the field. Regular consumption of poisoned pork may exceed the recommended daily intake of fluoroacetate and be a risk to human health, but there is a low probability of this occurring.

INTRODUCTION

Sodium fluoroacetate (1080) is a widely used toxin for control of vertebrate pests, in Australia. Given that a large dose of 1080 may be required to kill feral pigs, (e.g. O'Brien 1988), a high concentration of fluoroacetate residue may be found in the tissues of a poisoned animal (O'Brien *et al.* 1987). The levels of fluoroacetate found in carcasses should be investigated to assess if fluoroacetate pig baiting campaigns constitute a significant secondary poisoning risk threat to non-target species, to ensure the responsible and sustainable use of fluoroacetate.

The potential for secondary poisoning of non-target species depends on 1) exposure to and consumption of fluoroacetate residue by non-target species, 2) the susceptibility of the non-target animal consuming the tissue, 3) the concentration of 1080 in tissue, and 4) the amount of tissue consumed. In this paper we present preliminary findings on the distribution and concentration of fluoroacetate in pig carcasses, and assess the secondary poisoning risk to a variety of likely non-target consumers based on their susceptibility.

METHODS

1. 1080 residues

Samples were collected during routine poisoning campaigns. Landholders free-fed areas with non-toxic grain for up to one week. Once regular consumption of the free-feed by feral pigs was occurring, 1080-impregnated fermented wheat (288mg 1080/kg wheat) was substituted. The following morning, carcasses were located and the following samples collected: liver, kidney, stomach, stomach contents, small intestine, large intestine, muscle and eye. Samples were frozen (-10^0C) until analysis. Fluoroacetate present in the samples was extracted in water and were then cleaned up and concentrated using anion-exchange chromatography. The fluoroacetate dichloroanilide derivative was prepared by reaction of the acidified eluent with 2,4-dichloroaniline in the presence of N,N'-dicyclohexylcarbodiimide. The resulting fluoroacetate dichloroanilide derivative was extracted with ethyl acetate and following clean up and drying was quantified using a gas chromatography mass-spectrometry system (Agilent 5973). Quantitation is by single ion monitoring of the major ion at m/z = 186, with confirmation using the 70eV electron impact mass spectrum. The level of determination for this method in animal tissue was 0.005 ug/g. Fluoroacetate results are reported as the sodium fluoroacetate equivalent.

2. Susceptibility of non-target species

The risk of secondary poisoning to non-target species was assessed through comparing the fluoroacetate residue concentration in specific tissues with the lethal dose of a number of likely non-target consumers. The lethal 1080 dose for these animals was calculated from published LD_{50} values and expected adult bodyweights (Table 2). The susceptibility of each species was based on the weight of tissue to be consumed to obtain this dose based on the maximum amount of fluoroacetate residue in various pig tissues. Animals were classified as being at potential risk if the calculated amount required for a lethal dose was <15% of their bodyweight, suggesting an ability to consume this amount in a single feed (following L. Twigg pers. comm.).

3. Carcass degradation and visitation by non-target animals

Between September and December 2004 the longevity of non-poisoned feral pig carcasses was assessed in semi-cleared grazing country at Inglewood, south-western Queensland. Their longevity was investigated through general descriptions of their state of decomposition and recording carcass weights. The species visiting and consuming carcasses were identified via remote digital or video cameras or by track plots.

RESULTS

1. 1080 residues and distribution

The tissues of six pigs poisoned from 1080 grain-baiting operations were assayed. Residues were found in all samples. The distribution of residue within each individual was largely consistent; the highest concentrations were in the stomach contents, followed by the stomach, intestines, eyeball, muscle, and liver/ kidney respectively. The actual concentrations of sodium fluoroacetate in the various tissues were highly variable, ranging between 0.0031 to 87.3ug/g in muscle and stomach contents respectively (Table 1).

Table 1: Fluoroacetate concentrations (ug sodium fluoroacetate/g sample) in tissues collected from lethally poisoned pigs in grain-baiting operations.

Pig ID	1	2	3	4	5	6
Sex	M	M	M	M	F	F
Bodyweight	38	45	41	38	17.5	18
Distance from bait station	359m	47.8m	177m	430m	190m	195m
Liver	0.102	0.047	0.031	0.328	0.761	3.070
Kidney	0.194	0.078	0.127	0.937	1.640	1.390
Stomach	60.700	10.600	11.200	20.200	29.200	49.300
Stomach contents	82.700	15.000	28.800	64.400	87.300	43.000
Small intestine	1.980	0.466	0.423	1.630	4.050	3.980
Large intestine	2.000	0.543	1.760	2.500	10.80	3.340
Eyeball	0.680	0.372	0.860	1.050	3.360	1.240
Muscle	0.211	0.084	0.419	0.703	2.600	1.560

2. Susceptibility of non-target species

The amount of sodium fluoroacetate required to receive a lethal dose (based on LD_{50}), and the amount of muscle, visceral tissue or stomach contents to be consumed to obtain this dose of fluoroacetate was calculated for a range of likely non-target species (Table 2).

Table 2: Amounts of fluoroacetate tissue non-target species would have to ingest to receive an LD_{50} (* where amount needed to be consumed for LD <15% of bodyweight)

Species	Adult body mass (g)	LD_{50}	Amount of 1080 (mg) for LD_{50}	Muscle (max) = 2.60ug/g	Visceral (max) = Stomach = 60.7 ug/g	Stomach contents (max) = 87.3 ug/g
Introduced mammals						
Fox (*Vulpes vulpes)*	5000	0.13	0.65	250g*	10.71g*	7.45g*
Sheep/cattle dog (*Canis familiarus)*	15000	0.11	1.65	634.6g*	27.18g*	18.90g*
Feral pig (*Sus scrofa*)	40000	1.0	40.00	15384.6g	658.98g	458.19g*
Cat (*Felis catus*)	4200	0.40	1.68	646.2g	27.7g*	19.2g*
Birds						
Wedge-tailed eagle (*Aquila audux*)	3200	9.49	30.37	11680.8g	500.3g	347.9g*
Little raven *(Corvus mellori*)	550	3.1	1.71	657.7g	28.2g*	19.58g*
Australian Raven (*Corvus coronoides*)	600	5.1	3.10	1192.3g	51.1g*	35.5g*
Australian magpie-lark (*Grallina cyanoleuca*)	100	8.83	0.88	338.5g	14.5g*	10.1g*
Australian magpie (*Gymnorhina tibicen*)	320	9.93	3.18	1223.1g	52.4g	36.4g*
Little crow (*Corvus bennetti*)	390	13.37	5.21	2003.8g	85.8g	59.7g
Black kite (*Milvus migrans*)	590	18.51	10.92	4200g	179.9g	125.1g
Laughing kookaburra (*Dacelo novaguineae*)	300	~6.0	1.80	692.3g	29.7g*	20.6g*
White-winged chough (*Corcorax melanorhamphos*)	330	1.75	0.5775	222.1g	9.5g*	6.6g*
Pied currawong (*Strepera graculina*)	300	13.1	3.93	1511.5g	64.7g	45.0g
Reptiles						
Monitor (*Varunus* sp.)	2.5	27.5	68.75	26442.3g	1132.6g	787.5g
Lace Monitor (*Varunus varius*)	3600	43.6	157.0	60384.6g	2586.5g	1798.4g
Sand Monitor (*Varunus gouldii*)	840	43.6	36.63	14088.5g	603.5g	419.6g
Shingle-back lizard (*Tiliqua rugosa*)	470	205.9	96.8	37230.7g	1594.7g	1108.8g
Native mammals						
Spotted-tailed quoll (*Dasyurus maculatus*)	2800	1.85	5.18	1992.3g	85.3g*	59.3g*
Northern quoll (*Dasyurus hallucatus*)	5660	6.0	33.96	13061.5g	559.5g*	389.0g*
Brushtail possum (*Trichosurus vulpecular*)	2600	0.67	1.74	669.2g	28.7g*	19.93g*

Species sensitivity (LD_{50}) and body masses obtained from (McIlroy 1982a; McIlroy 1982b; McIlroy 1983; McIlroy 1984).

3. Carcass degradation and visitation by non-target animals

Carcasses degraded rapidly, with very little edible tissue remaining 7-10 days after death. Carcasses usually showed signs of insect activity (blowfly maggots and ants) within 24 hours, and began to liquefy after 3-5 days. Lace monitors (*Varianus varius*) were the main non-target species observed consuming carcasses, often dragging the entrails from the site for further consumption. Corvids (especially crows) and raptors (wedge-tailed eagles) were also frequently observed on carcasses.

DISCUSSION

As sampling was conducted as a follow up to a routine baiting operation the amount of bait consumed by each animal was unknown. The tissue residue levels observed in this study are likely to represent the maximum from 1080 baiting at the given bait concentration (288 mg 1080/kg) since excessive consumption of bait was encouraged by free-feeding. Additionally, stomachs from pigs were consistently full, suggesting that little vomiting had occurred and therefore, a large proportion of the ingested dose would be retained in the carcass. Despite differences in methodology and bait concentration, these residue levels in muscle (2.6 ug/g) are similar to the maximum values recorded in free-ranging pigs (2.42 ug/g) (L. Twigg pers. comm.) and in penned pigs (2.9 ug/g) (P. O'Brien pers. comm.) subjected to 1080 poisoning.

Based on the residue level of 2.6 ug/g, there appears to be little risk to native Australian animals from consuming muscle from poisoned pigs. All native species examined in Table 2 need to consume in excess of 15% of their bodyweight to be at risk from eating muscle tissue. Of the introduced mammals, dogs and foxes are most susceptible requiring consumption of less than 5% of their bodyweight in muscle for a lethal dose (Table 2). However, the much higher concentrations found in the viscera and stomach contents suggest that there is a potential poisoning risk to many native animals from consuming these tissues.

Despite the potential risk, few non-target animals were confirmed to consume carcasses by remote photography. Goannas readily consume flesh including viscera, but are at low risk due to their high tolerance to fluoroacetate. However their feeding habits may increase the exposure of other species to visceral tissues, increasing their likelihood of secondary poisoning. Despite anecdotes suggesting a low impact on secondary consumers, further assessments should be undertaken to assess the extent that non-target species consume such tissues.

In the seasons tested, feral pig carcasses largely did not persist for longer than 7 days, regardless of whether it was partly consumed by non-target species or not, supporting similar work completed in Western Australia (L. Twigg pers. comm.). This suggests that, at least in warm conditions, carcasses will not persist and represent a long-term food source. Additionally, defluorination will occur within the tissues, further reducing the fluoroacetate content and concentration. Under cooler conditions 1080 poisoned carcasses can persist for extended periods (Meenken and Booth 1997). Obviously the environmental conditions need be considered when assessing the longevity of, and secondary poisoning risk associated with poisoning operations.

Feral pigs are widely harvested in Australia for human consumption. Given the residue concentrations found in muscle, is there a risk to humans from consuming poisoned pig tissue? On heating, fluoroacetate becomes unstable above 110 ^{0}C and decomposes completely at 200 ^{0}C. These temperatures are rarely reached in food cooking, particularly with the modern tendency to undercook meats for better flavour. Most cooking of meat is done in the range of 70 to 180 ^{0}C meaning much of the fluoroacetate will remain present for human consumption. Given the maximum sodium fluoroacetate concentration in muscle was 2.6 ug/g, and using an approximate human LD_{50} of 2.0mg/kg, an 80kg male would have to consume >61 kg of muscle in a single sitting to consume a lethal dose – obviously impossible. The lethal dose is only one aspect of the toxicity however. Sodium fluoroacetate has both chronic and acute effects on organisms. Assuming a meal of 300 g of poisoned pork, our 80kg male would be consuming 0.78 mg fluoroacetate, or a dose of 0.00975 mg/kg. This is above the acceptable daily intake of sodium fluoroacetate, determined as 0.0002 mg/kg/day (Reference Dose determined by the United States Environmental Protection Agency 1995).

Despite that there may be some theoretical human health risk from consuming poisoned feral pigs, is there a practical risk? Given that the residues in this study are from lethally poisoned pigs, and such pigs are generally found close to the bait station (Table 1; J. Conroy pers. comm.) it is unlikely that these pigs would be harvested. The probability of being harvested (and consumed by humans) would be greater where the animal survives poisoning operations; residues in surviving animals are lower (Gentle unpublished data) as fluoroacetate is rapidly excreted further reducing the risk. These factors suggest that unless harvesters are operating in the vicinity of a poisoning program, there is a low probability of harvesting 'contaminated' pigs. In addition we can minimise this risk further through using temporal and spatial withholding zones. Conservatively, withholding periods of 30 days would be advisable to avoid harvesting pigs from poisoned areas. However, pigs being large, mobile animals may move considerable distances from the baited site. Therefore, it may be advisable to extend withholding periods to adjacent properties to ensure that migrating pigs are not accidentally harvested.

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