

BAIT UPTAKE BY FREE LIVING BRUSH-TAILED PHASCOGALES *PHASCOGALE TAPOATAFA* AND OTHER NON-TARGET MAMMALS DURING SIMULATED BURIED FOX BAITING

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Field trials were undertaken in box-ironbark woodland at Puckapunyal Military Area (PMA) in central Victoria between January 2000 and April 2001 to assess bait uptake by the brush-tailed phascogale (*Phascogale tapoatafa*) and other small mammals during simulated fox baiting exercises. The systemic marker Rhodamine B was used in non-toxic fox baits (Foxoff®) to detect non-target bait consumption. The trials demonstrated that free-living brush-tailed phascogales, yellow-footed antechinus (*Antechinus flavipes*), sugar gliders (*Petaurus breviceps*) and common brushtail possums (*Trichosurus vulpecula*) were capable of accessing non-toxic fox baits buried under 10 cm of sand. Rhodamine B markings were detected in six (15%) of 40 *P. tapoatafa* captured during the study period. The implications of these results and future research needs are discussed.

Key words: *Phascogale tapoatafa*, bait uptake, rhodamine B, fox baiting, target specificity.

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BAITING with the vertebrate pesticide 1080 (sodium monofluoroacetate) is widely used to control introduced predators such as foxes (*Vulpes vulpes*) and wild dogs (*Canis lupus familiaris*) in Australia (Saunders *et al.* 1995). There is increasing evidence from Western Australia, where many native species are tolerant to 1080 (Twigg 1994), that broad-scale poison baiting effectively reduces fox abundance, with benefits for a range of native fauna (Kinnear *et al.* 1988; Friend 1990; Morris *et al.* 1995). However the issue of impacts of poisoning programs on non-target wildlife populations remains an ongoing concern (Soderquist and Serena 1993; McIlroy 1994; Belcher 1998; Dexter and Meek 1998; Environment Australia 1999; Fairbridge and Fisher 2001; Glen and Dickman in press; Marks *et al.* in press; Martin *et al.* 2002).

In south-eastern Australia native species have a lower tolerance to 1080 than their con-specifics in the west and certain carnivorous or omnivorous native animals have the potential to eat lethal amounts of fox bait (McIlroy 1981, 1986, 1994; Belcher 1998; Fairbridge *et al.* 2000; Martin *et al.* 2002). Whether they do or not depends on a suite of interacting factors including sensitivity to 1080, body size,

method and rate of bait deployment, degradation of 1080 in laid baits (Saunders *et al.* 2000), the amount of bait an individual could eat (McIlroy 1994) and the likelihood that individuals will encounter a bait. Seasonal and behavioural factors, the availability of food resources and individual food preference may also influence bait consumption.

Canids commonly cache and re-excavate surplus food (MacDonald 1977; Saunders *et al.* 1999; van Polanen Petel *et al.* 2001). By deploying buried baits, this behaviour has been exploited to increase the target specificity of 1080 baiting programs (Allen *et al.* 1989; Saunders *et al.* 1995) and in Victoria fox baits are buried at a depth of 8 – 10 cm (Bloomfield 1999). Burial of baits has been shown to reduce bait uptake by native birds and small mammals in a number of studies (Allen *et al.* 1989; Staples and McPhee 1995; Dexter and Meek 1998; Thomson and Kok 2002) and buried baiting is considered an important strategy in reducing non-target exposure. However, there have been relatively few studies on the ability of different native species to locate and consume buried baits in the field (Allen *et al.* 1989; Belcher 1998; Dexter and Meek 1998; Fairbridge *et al.* 2000).

Dasyurids are thought to be potentially at risk of primary poisoning during 1080 predator baiting (Sinclair and Bird 1984; McIlroy 1986; Soderquist and Serena 1993; Belcher 1998). The spotted-tailed quoll (*Dasyurus maculatus*) for example, may be at risk during buried 1080 baiting operations if baits are not buried at sufficient depth (Belcher 1998; Glen and Dickman in press). Like *D. maculatus*, the brush-tailed phascogale (*Phascogale tapoatafa*) is listed as "Threatened" in Victoria (NRE 1997) and is a native carnivore which generally has a large home range (up to 100 ha, Traill and Coates 1993; Soderquist 1995; NRE 1997; Scarff *et al.* 1998). *P. tapoatafa* is relatively sensitive to 1080 (ALD of 6 mg kg⁻¹, Martin *et al.* 2002) but has been considered to have a low probability of primary or secondary poisoning from ground placed meat baits, being largely arboreal and insectivorous (J. McIlroy pers. comm.). Nevertheless, *P. tapoatafa* has been observed foraging at ground level and may take small vertebrate prey and carrion (Scarff *et al.* 1998; R. Anderson pers. obs.).

In Victoria, *P. tapoatafa* occurs predominantly in dry forest and woodlands (NRE 1997) and broad-scale fox control in these habitats has the potential to benefit a range of prey or competitor species (Coman *et al.* 1995; Friend *et al.* 2001). However, because *P. tapoatafa* may occur at low densities (Traill and Coates 1993; Soderquist 1995) the consequences for localised, isolated populations may be serious if individual animals consume baits and their survival is adversely affected as a result. Determining if wild-living *P. tapoatafa* have the opportunity to consume buried baits is an essential first step in defining the risk faced by *P. tapoatafa* during 1080 fox baiting in Victoria. Here we report on a study using the marker Rhodamine B to assess the ability of *P. tapoatafa* and other small mammals to locate and consume non-toxic fox baits buried in the field.

METHODS

Study site

Puckapunyal Military Area (PMA) (36° 55'S, 145° 00'E) occupies about 440 km² of box-ironbark forest and woodland in central Victoria. Much of the original vegetation within PMA has been cleared for stock grazing prior to acquisition by the Department of Defence but approximately 40% of the area remains as original or regrowth box-ironbark forest. Within the cleared area of PMA there are also significant woodland remnants on ridges and in gullies. PMA is managed by the Department of Defence and is one of the most heavily used military training areas in Australia. The site is a registered 'Land for Wildlife' property and acts as an important reserve supporting a range of flora, fauna and

communities of national, state, regional and local significance (Department of Defence 1996). Since the 1970s the Department of Defence has carried out an active program of environmental rehabilitation and management at PMA. A large-scale fox control program using Foxoff[®] baits was commenced in 1994 (Department of Defence 1996). An annual baiting program has continued and monitoring of a wide range of potential fox prey species commenced in 1995.

Baiting and trapping

Simulated buried baiting using non-toxic baits took place at four separate box-ironbark woodland remnants within PMA during summer and autumn 1999/2000 and again in summer and autumn 2000/2001. This timing was necessary to fit in with the military training schedule at the site. It also coincided with the period when fox baiting was normally carried out at PMA and juvenile *P. tapoatafa* became independent and began dispersing into new territories, potentially a period of high risk of exposure to baits. Three of the remnants ('Wells Ridge', 'Twin Tree Hill' and 'Grenade Range 2') were approximately 1 km² in area and the fourth ('Route 25') was a linear remnant of approximately 0.3 km². All sites were known to contain populations of *P. tapoatafa* and the yellow-footed antechinus *Antechinus flavipes*.

Foxoff[®] (Animal Control Technologies, Melbourne) was selected as the trial bait because it is used at PMA for fox control and is widely used across south-eastern Australia (Saunders *et al.* 1999). This study was not intended to provide an evaluation of fox bait types, rather to investigate whether *P. tapoatafa* had the propensity to eat fox baits deployed in buried bait stations. At each woodland site, 12 - 16 bait stations were established through the middle of the remnant in two parallel transects separated by approximately 100 m with stations set at 50 m intervals. This was not typical of baiting practice at PMA where woodland areas are usually avoided. The bait density was also higher than in most baiting operations but was designed to ensure all resident *P. tapoatafa* had the opportunity to encounter at least one bait station when foraging on the ground or moving between trees.

Rhodamine B is an effective and reliable marker in mammals which, when consumed, produces persistent systemic markings in hair that are detectable as fluorescent bands under ultra violet light (Fisher *et al.* 1999). These properties make Rhodamine B a suitable marker for assessing bait uptake in native mammals as sampling is relatively non-invasive and quick (Fisher 1999).

Prior to deployment, 35 g non-toxic Foxoff baits were impregnated with 20 mg of Rhodamine B in an aqueous solution (40 mg ml⁻¹). A small well was drilled in each bait and 0.5 ml of Rhodamine B solution was added. In the field, baits were placed in a hole 10 cm below the ground surface and covered with fine building sand, slightly mounded to ensure that there was 10 cm of material covering the upper surface of the bait. Further sand was added to create a 1m diameter pad. The baiting simulations ran for approximately 3 - 5 weeks during each trial. Bait stations were checked every 3 - 7 days and baits replaced if taken. Any disturbance to the stations including diggings, prints, scats or bait takes was recorded and the stations raked smooth. Animal signs at bait stations were identified using methods described by Triggs (1996). Due to Army training activities it was generally not possible to check the bait stations daily. Two weeks after the end of each baiting trial small mammal trapping was conducted at the sites as part of the monitoring program at PMA.

At each site a straight-line transect of 25 medium Elliott traps (Elliott Scientific Equipment, Melbourne) was established with an interval of approximately 20 m between each trap. Traps were set on the ground and baited with a mixture of rolled oats, honey, peanut butter, dried fruit, sardines and dog food. All trap lines were inspected twice (at dawn and again in the late afternoon) during each 24-hr period and remained open for five days and nights. When first captured animals were weighed, sexed and marked on the sole of the hind foot using a permanent pen to identify recaptures. Bait uptake was indicated by the presence of characteristic fluorescent marking (bands) in the vibrissae (Fisher 1999). To detect the presence of Rhodamine B attributable to bait uptake, samples of eight mystacial vibrissae (whiskers) were plucked from each trapped animal using forceps so that the entire whisker was removed from the follicle. This procedure was carried out without anaesthesia by competent and experienced field staff (with approval of the Victorian Institute of Animal Science Animal Ethics Committee). Whisker sampling of small mammals is a brief process that does not cause an unacceptable amount of pain or distress to the animal (Fisher 1998). The loss of whiskers is temporary as plucking stimulates regrowth of hair (Chase 1954). Following processing, animals were released at the point of capture. The samples were stored in labelled sealed envelopes for later mounting and detection of marking. Vibrissae samples were prepared, mounted and examined at 10 x magnification using a fluorescence microscope as described by Fisher *et al.* (1999).

RESULTS

A combined total of 38 *P. tapoatafa*, 36 *A. flavipes*, two sugar gliders (*Petaurus breviceps*), three

common brushtail possums (*Trichosurus vulpecula*) and three common dunnarts (*Sminthopsis murina*) were captured. Two *P. tapoatafa* caught in January 2000 were recaptured in March 2000 but were included in the sample as new animals for that trapping session because each separate baiting and trapping session was considered to be independent.

Rhodamine B marking was detected in six (15%) *P. tapoatafa* (1 male, 5 females), seven (19%) *A. flavipes* (4 males, 2 females, 1 not sexed), both *P. breviceps* (1 male, 1 female) and all three *T. vulpecula* (3 males). Table 1 shows bait uptake by non-target species at all sites and all four trials. The total number of baits set during each trial (bait availability) is also shown.

In the first trial (January 2000) overall bait take by all species was 40% with 23 baits taken out of 60 set. Bait take increased during later trials (Table 1) with the highest rate occurring in autumn 2000 (85%). Inability to check the bait stations each day made interpretation of prints and signs on sand pads difficult. The high number of bait takes recorded as unidentified species reflected the indistinct nature of tracks and other signs on sand pads following weathering or disturbance by several animals visiting the bait station. During all trials only six non-target bait takes were clearly identified from examination of sand pads. These were five incidences of *T. vulpecula* or *P. breviceps* having excavated a bait station and one observation of *P. tapoatafa* having excavated a bait (tracks were observed on a bait station where the bait had been removed). Tracks of *P. tapoatafa* were observed on intact bait stations on three occasions.

All but one of the six marked *P. tapoatafa* was female and four of the females were adults. Five of the samples showed only a single fluorescent band of Rhodamine B and one female had two fluorescent bands, one at the tip of a whisker and one at the base. The highest level of bait uptake by *P. tapoatafa* was recorded in January 2000 (of 13 caught three individuals were marked). Bait uptake by *A. flavipes* was detected in March 2000 (two marked of five animals caught) and April 2001 (five marked of 22 caught). Marking in *P. breviceps* and *T. vulpecula* confirmed earlier observations of bait excavations by these species. Table 2 summarises the characteristics of all the marked non-target animals.

DISCUSSION

The trials demonstrated that *P. tapoatafa*, *A. flavipes*, *P. breviceps* and *T. vulpecula* were capable of consuming non-toxic fox baits originally buried under 10 cm of sand in field conditions. It was not possible to determine if non-target exposure to baits was primary (i.e., directly excavated from bait stations) or secondary (accessed following removal

Trial	Total baits set (bait stations)	Bait take			Unidentified bait take (%)	Trapping results			
		Total bait take (%)	Fox bait take (%)	Non-target bait take (%)		<i>P. tapoatafa</i>		<i>A. flavipes</i>	
					# caught	# marked (%)	# caught	# marked (%)	
January 2000	60 (48)	24 (40)	15 (25)	0	9 (15)	13	3 (23)	1	0
March 2000	233 (48)	197 (85)	125 (53)	0	72 (31)	4	1 (25)	5	2 (40)
January 2001	145 (56)	93 (64)	29 (20)	*5 (3.4)	59 (40)	13	1 (8)	8	0
April 2001	394 (56)	250 (63)	134 (34)	0	116 (29)	10	1 (10)	22	5 (23)
Totals	832	564 (67)	303 (36)	5 (0.6)	256 (30)	40	6 (15)	36	7 (19)

Table 1. Combined bait uptake and trapping results for *P. tapoatafa* and *A. flavipes*. The number of baits set includes the initial number of baits plus those replaced when a bait was taken or deteriorated. * Non-target tracks identified were 1 *P. tapoatafa* and 4 *T. vulpecula* or *P. breviceps* (these species were not distinguished).

Species	Trial	Site	Sex	Weight (g)	Age class	Rhodamine B bands
<i>P. tapoatafa</i>	Jan. 2000	Wells Ridge	M	80	juvenile	1
<i>P. tapoatafa</i>	Jan. 2000	Wells Ridge	F	130	adult	1
<i>P. tapoatafa</i>	Jan. 2000	Twin Tree Hill	F	166	adult	1
<i>P. tapoatafa</i>	Mar. 2000	Wells Ridge	F	100	juvenile	2
<i>P. tapoatafa</i>	April 2001	Wells Ridge	F	149	adult	1
<i>P. tapoatafa</i>	April 2001	Wells Ridge	F	131	adult	1
<i>A. flavipes</i>	Mar. 2000	Twin Tree Hill	M	29	-	1
<i>A. flavipes</i>	Mar. 2000	Twin Tree Hill	M	40	-	1
<i>A. flavipes</i>	April 2001	Route 25	F	15	juvenile	4
<i>A. flavipes</i>	April 2001	Route 25	M	40	adult	2
<i>A. flavipes</i>	April 2001	Route 25	-	-	-	2
<i>A. flavipes</i>	April 2001	Route 25	F	23	juvenile	4
<i>A. flavipes</i>	April 2001	Route 25	M	36	adult	1
<i>P. breviceps</i>	Jan. 2001	Grenade 2	M	-	juvenile	1
<i>P. breviceps</i>	Jan. 2001	Grenade 2	M	-	adult	1
<i>T. vulpecula</i>	April 2001	Wells Ridge	M	487	juvenile	1
<i>T. vulpecula</i>	April 2001	Twin Tree Hill	F	490	juvenile	1
<i>T. vulpecula</i>	April 2001	Twin Tree Hill	F	531	juvenile	1

Table 2. Characteristics of individual non-target animals marked with Rhodamine B banding during all trials (January 2000 – April 2001).

of bait from a station by another animal). Tracks of three non-target species (*P. tapoatafa*, *P. breviceps* and *T. vulpecula*) were observed on bait stations where baits had been removed suggesting that some individuals did excavate baits. However, foxes have been shown to readily cache Foxoff and dried meat baits and this may be an important contributor to bait availability to non-target species (Saunders *et al.* 1999; van Polanen Petel *et al.* 2001; Thomson and Kok 2002).

Identification of sign and prints at buried bait stations is often used to determine the animal species responsible for bait take. However, a number of studies have highlighted the difficulty in interpreting

such signs (McIlroy 1986; Belcher 1998; Fairbridge *et al.* 2000; Glen and Dickman in press). Using Rhodamine B, eighteen non-target bait takes were detected during all trials whereas identification of sign on sand pads only detected six likely non-target takes and it was not possible to determine from tracks how many non-target animals were responsible for the bait take observed.

Acceptance of a bait does not always mean it was ingested (van Polanen Petel *et al.* 2001). Even where removal of baits by non-targets can be identified by examination of bait stations or remote photography (e.g., Belcher 1998; Glen and Dickman in press), bait consumption cannot be confirmed using these

methods. Bait uptake studies using markers, however, can give an accurate assessment of non-target bait uptake since they provide unequivocal evidence of at least partial bait consumption.

Although it was not possible to determine accurately how much bait was eaten by each marked animal it is reasonable to assume that any Rhodamine B marking detected in species such as *P. tapoatafa* and *A. flavipes* represents a potentially lethal bait consumption. In Western Australia, the approximate lethal dose (ALD) for *P. tapoatafa* has been determined to be 5.99 mg kg⁻¹ of pure (100%) 1080 (Martin *et al.* 2002). The ALD is the lowest dose causing death or severe symptoms in a laboratory trial (Calver *et al.* 1989). Based on their weight (80 – 166 g) and this ALD figure the marked animals in our trials would have required between 0.48mg and 0.96 mg of 1080 for an approximate lethal dose (15 – 30% of the 1080 contained in one fox bait). This is a conservative estimate since dasyurids in eastern Australia are known to be more sensitive to 1080 than those in Western Australia (Twigg 1994; Martin *et al.* 2002). In Western Australia two phascogale species *P. calura* and *P. tapoatafa* consumed between 0.1 and 8.3 g of Foxoff daily (Martin *et al.* 2002). While these amounts can be considered very small, a consumption of 8.3 g would constitute a theoretical ALD for some individuals if 1080 was uniformly distributed through the bait. For small mammals that may eat only a small amount of bait, the distribution of 1080 within the bait matrix may determine whether a lethal dose is ingested. If the poison remains in the centre of the bait, the risk to small non-target species may be reduced if only the external surface is eaten. Smaller baits are more easily handled by small animals and the toxin is more concentrated (Martin *et al.* 2002). Increasing bait size may be an important strategy in reducing the potential risk to small dasyurids.

Once buried in the field the concentration of 1080 in baits declines due to a range of environmental factors of which rainfall appears to be the key (Saunders *et al.* 2000). The temporal loss of 1080 from baits is considered to be an advantage as non-target risk is reduced over time. However, the degradation rate is highly variable and in dry conditions baits can remain toxic to foxes for up to 11 weeks (Saunders *et al.* 2000) suggesting that cached baits or baits left in the soil for extended periods of dry weather may pose a non-target hazard (Saunders *et al.* 2000).

The results of the January 2000 trial, that showed 3 out of 13 trapped *P. tapoatafa* marked with Rhodamine B, were of some concern (two of the marked animals were adult females). When these animals were trapped only 23 bait takes had been

recorded across all sites. At one site, 'Wells Ridge' only three baits were removed prior to trapping during the January trial. At this site eight *P. tapoatafa* were subsequently trapped and two females were marked.

A number of factors may have contributed to the non-target bait uptake observed. Time of year may be critical in determining whether dasyurids are likely to take a bait (Soderquist and Serena 1993; Martin *et al.* in press). Our trials were run during summer and autumn when juveniles were becoming independent and moving into new territories. Adult females may have been nutritionally stressed for part of this period. At such demanding times both juvenile and adult animals may be more likely to feed on baits if they encounter them (Soderquist and Serena 1993; Scharff *et al.* 1998).

The hardness of the bait is likely influence consumption by non-target species. Small dasyurids lack the dentition to eat substantial amounts of dried meat baits. However, softer baits are likely to be more easily handled and consumed by small non-target mammals (Martin *et al.* 2002). Following the recent introduction of foxes to Tasmania, Western Australian dried meat baits (DMBs) have been used in the fox eradication program because they are considered less palatable to smaller non-target species (T. Bloomfield pers. comm.). The potential of hard dried meat baits for use in the other eastern states in areas where non-target risk may be high requires further investigation.

Reduced predation pressure by foxes can result in a change in behaviour of some prey species (Banks 2001). At PMA there is considerable evidence to suggest that *P. tapoatafa* and other species have responded to a reduction in fox numbers following baiting, by spending more time foraging at ground level (R. Anderson unpubl. data). This may mean, paradoxically, that their potential for exposure to fox baits is higher. Phascogales forage actively over large home ranges (30 – 60 ha for females and up to 100 ha for males, Traill and Coates 1993; Soderquist 1995; Scharff *et al.* 1998) increasing the likelihood that individuals will encounter one or more baits. (Soderquist and Serena 1993; Belcher 1998). Even at baiting densities of 5 baits km⁻² individuals may encounter several baits.

Studies on free living *P. tapoatafa* in Western Australia (Scharff *et al.* 1998) and Victoria (Traill and Coates 1993; Soderquist 1995) have indicated that the species is essentially an arboreal insectivore that supplements its diet with nectar when available. This description alone would suggest that *P. tapoatafa* is unlikely to be at risk of consuming fox baits. However, these studies also report the species

foraging at ground level, scavenging on vertebrate carrion and occasionally taking live vertebrate prey. Our observations indicate that *P. tapoatafa* at PMA may spend up to 40% of their foraging time on the ground during summer (R. Anderson unpubl. data). In view of the inquisitive nature of *P. tapoatafa* (R. Anderson pers. obs.), the large areas over which they forage, their ability to forage on the ground and take a broad range of food, it is perhaps not surprising that some individuals located baits during our trials.

Bait uptake by *A. flavipes* (19%) was similar to that seen in *P. tapoatafa*. Its congener, the agile antechinus (*A. agilis*) is also known to consume buried Foxoff baits in the field (Fairbridge *et al.* 2001). *A. flavipes* is an opportunistic insectivore (also taking small vertebrates) foraging on tree trunks, logs, stumps and in the litter layer (Menkhorst 1995) suggesting that individuals are at risk of exposure to baits if bait stations are placed within their home range. The home range of *A. flavipes*, however is considerably smaller than that of *P. tapoatafa* (recorded movements range from 42 – 94 m, Smith 1984) and bait exposure is likely to be localised around bait stations. The sensitivity of *A. flavipes* to 1080 has not been assessed however, the brown antechinus (*A. stuartii*) requires only 0.07 mg of 1080 for an LD₅₀ (2% of the 1080 contained in one fox bait, McIlroy 1981).

Bait consumption by *P. breviceps* and *T. vulpecula* indicated that, like *P. tapoatafa*, individuals of both species spent some time foraging on the ground. *T. vulpecula* is known to spend a proportion of its time foraging at ground level (MacLennan 1984) and has been recorded consuming meat-based fox baits (Western Australian dried meat baits and “pro-bait”, a salami-type bait) in laboratory trials (Martin *et al.* 2002). More surprising is the observation that *P. breviceps* consumed buried Foxoff during our trials. *P. breviceps* predominantly feeds on invertebrates and plant exudates (Henry and Suckling 1984) but, while it has been recorded dispersing across treeless pasture (Suckling 1984), it is not known whether foraging at ground level is common behaviour.

The long-term home range of *P. breviceps* has been recorded as ranging from 0.5 – 5.0 ha (Quin 1995). Some individuals may forage over distances of up to 360 m (Henry and Suckling 1984) but more generally foraging radii range between 90 and 150 m (Henry and Suckling 1984). At the baiting rates recommended in Victoria (1 – 4 baits km⁻¹) it is unlikely that more than one bait station would occur within an individual’s home range. However, *P. breviceps* home ranges frequently overlap (Quin 1995) and, with regular bait replacement, it is conceivable that several individuals may encounter

baits at the same station during a fox control program.

From a population perspective, the impact of the loss of small numbers of individuals due to poisoning can be assessed in relation to the species’ resilience or ability to recover from additional mortality (Choquenot and Ruscoe 1999). Vulnerability to environmental uncertainty, dependence on annual breeding success and low population densities (Traill and Coates 1993; Soderquist 1995; Scarff *et al.* 1998) may make *P. tapoatafa* less resilient than more common species. At PMA the continued drought in south - eastern Australia coincided with a considerable reduction in the number of *P. tapoatafa* trapped at the monitoring sites (R. Anderson unpubl. data). At such times, populations are more vulnerable to the impact of additional mortality and the loss of even a single adult female due to poisoning may affect the recovery of isolated local populations.

Our baiting simulation deliberately exposed the trial sites to a high baiting density to increase the chances of detecting what may be a low incidence of bait consumption by non-target animals and to establish whether certain non-target species would eat baits. Baiting rates vary widely in Australia and are dependent on the nature of the site. The baiting density used in this study of 12 to 16 bait stations km⁻² was higher than in most baiting operations. For example, in Western Australia surface baits are laid at 5 baits km⁻² (Thompson and Algar 2000) and in Victoria the recommended rate is 1 – 4 bait stations km⁻¹ (Bloomfield 1999). It is worth noting that non-target bait uptake at individual sites in this study was generally low (1 – 5 marked animals) during each trial despite the relatively high baiting density. Nevertheless this preliminary study has identified a potential cause of mortality in *P. tapoatafa* and three other native species that has not been previously recognised.

Since broad-scale fox control was implemented at PMA monitoring has demonstrated a progressive decline in fox abundance across the site and an increase in the abundance and range of a number of fox prey or competitor species including *P. tapoatafa*, *T. vulpecula* and *A. flavipes* (R. Anderson unpubl. data). This suggests that there are significant benefits of fox control to be balanced against any costs in non-target losses. While the normal baiting practices at PMA may be sufficient to reduce potential exposure of non-target species to bait stations, this may not always be the case at other sites supporting populations of *P. tapoatafa* either on private or public land. The results of this study have particular implications for fox control undertaken for fauna protection in small remnants of forest and woodland where populations of non-target species

such as *P. tapoatafa* may be small and any additional sources of mortality may be significant. Small high quality remnants on fertile soils, such as roadsides, can provide good habitat for *P. tapoatafa* in fragmented agricultural landscapes (van der Ree *et al.* 2001). The location and design of bait stations are of critical importance in preventing non-target bait exposure at such sites.

While our observations suggest *P. tapoatafa* and three other non-target species may consume non-toxic baits, their reaction to baits containing 1080 is unknown. Intake of a small sublethal amount of 1080 may suppress appetite or lead to aversion in some dasyurids (Sinclair and Bird 1984). It cannot be assumed that lethal quantities of bait will be consumed once it is treated with poison. However, even sublethal doses of the toxin may potentially impact on local populations (Eason *et al.* 1994; Eisler 1995). Further work is needed to determine the reaction of *P. tapoatafa* and other non-target species to toxic baits (e.g., Kortner *et al.* 2002).

In the future, target-specificity is likely to be a key factor in determining the public acceptability of predator control techniques (Anon. 2001). To ensure maximum benefits of fox control it is important to continually monitor baiting methodologies and test some of the assumptions upon which they are based. The results presented here indicate that buried baiting is not always target specific and the factors that predispose non-target species to take fox baits are likely to be complex. The risk of non-target poisoning may vary from site to site or year to year depending on seasonal conditions. Bait station design, burial depth, caching behaviour, bait type and the ability of native species to detect 1080 are also likely to influence non-target uptake. Research efforts aimed at better understanding these factors are likely to lead to the development of more target-specific bait delivery systems for fox control.

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