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Does fox baiting threaten the spotted-tailed quoll, *Dasyurus maculatus*?

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Abstract. In Australia, baiting with 1080 (sodium fluoroacetate) is widely used to reduce predation of native wildlife by the red fox. However, such control programs may place some native carnivores at risk, particularly the spotted-tailed quoll in eastern Australia. We measured the mortality in a total of 57 quolls fitted with mortality radio-transmitters during four experimental fox baitings with Foxoff® 1080 baits containing Rhodamine B in north-east New South Wales. In all experiments quolls visited bait stations regularly and removed a total of 20 baits. All but one of these baits was found in the vicinity of the bait station, indicating that quolls did not ingest baits. This was confirmed by the absence of Rhodamine B in the vibrissae of all quolls retrapped after baiting. The only quoll that may have died from a bait had eaten a cached bait some six weeks after baiting concluded. Thus, baiting did not threaten any of the quoll populations sampled. Therefore it appears that most restrictions imposed to protect spotted-tailed quolls during fox baiting are unnecessary as long as this bait type is used.

Introduction

Since its introduction to Australia in the mid 1800s, the red fox (*Vulpes vulpes*) is believed to have played a major part in the extinction of many vertebrate species (Rolls 1969; Jarman 1986; Burbidge and McKenzie 1989), with potentially several more to follow (Dickman 1996; NPWS 2001). Therefore, fox control is thought necessary in many conservation areas and baiting with the toxin sodium fluoroacetate (compound 1080) appears to be the only feasible method for large-scale control (Saunders *et al.* 1995; NPWS 2001).

In parts of Western Australia, the Northern Territory and Queensland, 1080 is found naturally in a variety of plant species (Twigg and King 1991) and native animals in these areas have evolved some resistance to it (King *et al.* 1978; Mead *et al.* 1985). Such resistance is not known in the eastern States of Australia where the rare, carnivorous spotted-tailed quoll (*Dasyurus maculatus*) is thought to be at risk during fox-control programs (McIlroy 1981*b*; Belcher 1998). When measured in the laboratory, the sensitivity of this species to 1080 is such that while adult males have a good chance of surviving the ingestion of one fox bait (3 mg $bait^{-1}$), females and juveniles, which are considerably smaller (Jones *et al.* 2001), could die (McIlroy 1981*b*). Moreover, poor health and environmental conditions that raise the energy turnover of an animal (e.g. low ambient temperatures) can increase the susceptibility of individuals to 1080 (McIlroy 1981*a*; Oliver and King 1983). On the other hand, an ingested bait can be partly removed by vomiting (common response in carnivores to 1080) and the amount of 1080 in a bait will decrease from the time it is deployed (McIlroy *et al.* 1988; Fleming and Parker 1991; Saunders *et al.* 2000). Consequently, the sensitivity to 1080 measured under laboratory conditions is of limited use for predicting whether a quoll will die after consuming fox bait in the field.

Furthermore, the chance of bait encounter is an important factor determining the risk for an animal. Whether a quoll will find a bait depends on a number of parameters including bait density, duration and frequency of baiting, habitat structure, bait removal by other animals, and the size of the area baited in relation to home-range size. Also, bait encounter does not necessarily result in bait consumption. Palatability of bait, the hunger status of an animal and the availability of alternative food sources are all factors that may influence bait consumption and are probably highly variable within and between individuals, populations and seasons.

Some of these parameters can be addressed by simulated baiting trials using non-toxic baits. However, the lack of

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mortality amongst target and non-target species can change bait availability considerably, because it may facilitate the removal of many baits by a small number of individuals and increase visitation rates due to learning (Thompson and Fleming 1994). In addition, bait aversion in response to ingestion of a sub-lethal dose of 1080 has been described (Morgan *et al.* 1996; O'Connor *et al.* 1998) and for some mammals 1080 reduces the palatability of food (Morgan 1982; Sinclair and Bird 1984; Calver *et al.* 1989). Therefore, the consumption of non-toxic baits by quolls is likely to be a poor predictor of the impact of toxic baiting.

In summary, laboratory research and field trials with non-toxic baits are unlikely to provide a definitive evaluation of the consequences of fox baiting on spotted-tailed quoll populations. To provide an unambiguous answer to this question, we directly examined the mortality of free-ranging spotted-tailed quolls during fox-baiting programs.

Material and Methods

Study area

Four experiments were conducted: winter/spring 2000, autumn/winter 2001, winter/spring 2001 and autumn/winter 2002. The first two and the fourth were carried out in Werrikimbe National Park and Doyles River State Forest (31°12′S, 152°10′E), approximately 90 km south-east of Armidale. The third experiment was located at a similar distance east of Armidale, on the Petroi Plateau (30°37′S, 152°20′E), which is part of Cunnawarra and New England National Parks. Both study areas are on the eastern escarpment of the New England Tablelands, and have a diversity of habitats, including areas with dense forest and understorey, often regarded as the favoured habitat for spotted-tailed quolls (Edgar and Belcher 1995; Jones *et al.* 2001).

The history of predator control differs between the two study areas. There has been 1080 baiting for wild dogs using meat baits at the periphery of the study area in parts of Doyles River State Forest, although in 2001 this aerial baiting was replaced by ground baiting. In contrast, at Petroi wild dog control has been infrequent and restricted to trapping and shooting. However, on a property north of Petroi (2–3 km), regular 1080 dog baiting has recently started. Neither study area had been baited with the manufactured fox bait, Foxoff®, prior to our experiments.

Trapping and radio-tracking

Extensive trapping for spotted-tailed quolls was conducted prior to and after the baiting period. Up to 103 cage traps (30 × 30 × 60 cm; Mascot Wireworks) covered with plastic sheeting were set at intervals of 100–200 m along 20–30 km of roads and trails. Traps were usually set over 3–4 consecutive days (maximum 7). They were baited with chicken heads or wings and a mixture of canned dog and cat food was used as a lure. Traps were checked daily in the early morning and, initially, trapped quolls were processed and released immediately. However, because some individuals were trapped repeatedly over several consecutive days and the bait in the trap was not sufficient to cover their daily energy requirements, the procedure had to be adjusted slightly. The adjustment involved providing trapped quolls with several pieces of chicken and quolls were released 1–2 h later when they had consumed most of the extra food. All captured quolls were permanently marked with identification transponders (PIT tags, Destron Fearing Corp). Sex, body mass and health were determined and quolls trapped prior to baiting were fitted with mortality radio-collars (Sirtrack, ~30 g). These transmitters emit short radio-signals at a constant rate, which doubles when the transmitter has not been moved for more than 24 h.

Re-trapping quolls commenced 3–4 weeks after the baiting period to allow sufficient time for the bait marker (Rhodamine B, see below) to be incorporated into growing hair. Radio-collared quolls not recaptured during this time were radio-tracked individually and traps set at their den sites. This procedure proved only partly successful as quolls frequently left their resting place when approached. No radio-signal was received after baiting from five males and these animals were not re-trapped. Either their transmitters had failed (unlikely, because transmitter failure was observed only once) or the animals had moved far out of the study area.

Opportunistic pre-baiting radio-tracking (usually limited to 1–2 h per day, but more intensive towards baiting) was used to crudely determine movements and 'home ranges', which was useful when monitoring quolls during the baiting periods. Consequently, during baiting we were able to record the mortality status of most transmitters at least every second day, despite the fact that vegetation and rugged landscape often obscured radio signals. Radio-tracking effort decreased again one week after baiting was terminated. In the event of a mortality, the dead quolls were located and post-mortems were conducted (by an experienced veterinarian) on those that were not decomposed.

Baiting

At least a week prior to baiting, between 38 and 58 bait-stations (400-m intervals) were established along the same roads and trails as the quoll traps. These were offset from the trap locations by approximately 100 m. Fresh Foxoff® baits (nominal 3 mg 1080 and 50 mg Rhodamine B per bait) were used for each experiment. Either 5 or 10 baits were assayed for 1080 when fresh (first experiment: 3.25 ± 0.83 (mean ± s.d.) mg 1080 per bait, n = 5; second: 2.48 ± 0.49 mg 1080 per bait, n = 10; third: 2.74 ± 1.04 mg 1080 per bait, n = 10; fourth: 2.73 ± 0.68 mg 1080 per bait, n = 10) and after baiting was concluded. Only during the third experiment (Petroi) was a significant decrease in the amount of 1080 per bait detected (1.39 ± 0.28 mg 1080 per bait, n = 10). A bait was placed in the middle of the sand or soil plot (diameter ~1 m) of each bait station and only lightly covered to prevent removal by birds. During the fourth experiment half the bait stations (randomised) contained non-toxic baits (also including the bait marker) to investigate any possible affect of the toxin on the palatability of bait. Bait stations were checked daily for animal tracks and bait takes, and any baits removed were replaced. Baiting continued for 10 days, after which all remaining baits were collected.

A bait take was defined as bait removal (moved from its original location), or, in the case of small mammals, uncovered baits that had been bitten. Baits disturbed by lyrebirds or wombats were not regarded as bait takes, because these animals had apparently no interest in baits as food (bite or peck marks were never evident). Bait acceptance was defined as the percentage of detectable visits to bait stations that resulted in a bait take.

The bait marker Rhodamine B temporarily stains the mouth and gut and should have been obvious in any quoll succumbing to baiting. It is also incorporated into the growing hair of any animals surviving the ingestion of a bait and can be detected as a fluorescent band (Fisher 1998). Samples of eight vibrissae were collected from each quoll during post-baiting trapping and analysed for traces of Rhodamine B.

Predator counts

Predator numbers (quolls, foxes, dogs and cats) were estimated before and after baiting by counting the tracks crossing the track pads (beach sand or sifted soil) that were established across roads and trails. Pads covered the entire width of the trail, were at least 1 m wide and the ends were blocked with branches to prevent animals bypassing the pad. They were spaced at 600 m in the first experiment and 800 m thereafter, and were established at least six days before monitoring commenced to allow animals to become accustomed to them. Between 21 and 34 pads per site were employed during the four experiments, and were monitored for tracks over four nights before and after baiting, on consecutive nights unless prevented by rainfall. Pads were also checked opportunistically during the baiting itself.

Results

Quoll trapping and transmitter use

During the four experiments a total of 85 individual quolls were captured (there was some overlap between the three experiments conducted at Werrikimbe NP; Table 1). Pre-baiting trapping ceased when sufficient quolls had been fitted with radio-transmitters (>10 individuals; 1 mortality <10%) and no or very few new individuals were being captured. This required about five weeks of trapping (1338–2162 trap-nights). A similar length of time was required to retrieve the collars after the baiting ceased (1051–1959 trap-nights). During the post-baiting trapping in each experiment a number of new quolls (up to 10) was captured. These individuals, with one exception, were either juvenile animals or adult males. These patterns suggested dispersal and extensive movement amongst the male population even over relatively short periods.

Bait take

In total, 156 baits were taken during the combined 2040 bait-nights of the four trials. Most of these were attributed to foxes, but a substantial number was taken by small mammals, quolls and dogs (Fig. 1).

Table 1. Transmitter use
Numbers in parentheses refer to transmitters functional at the beginning of the baiting period

Experiment	Animals trapped	Transmitters fitted
1: Werrikimbe 2000	27	18 (15)
2: Werrikimbe 2001	35	25 (16)
3: Petroi 2001	15	13 (11)
4: Werrikimbe 2002	26	19 (15)

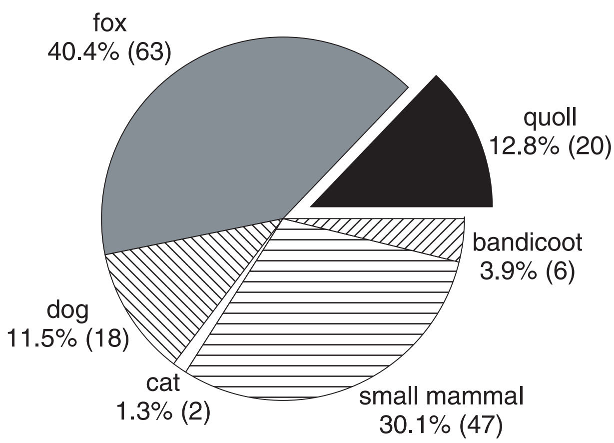

Fig. 1. Summary of bait takes for the four experimental trails.

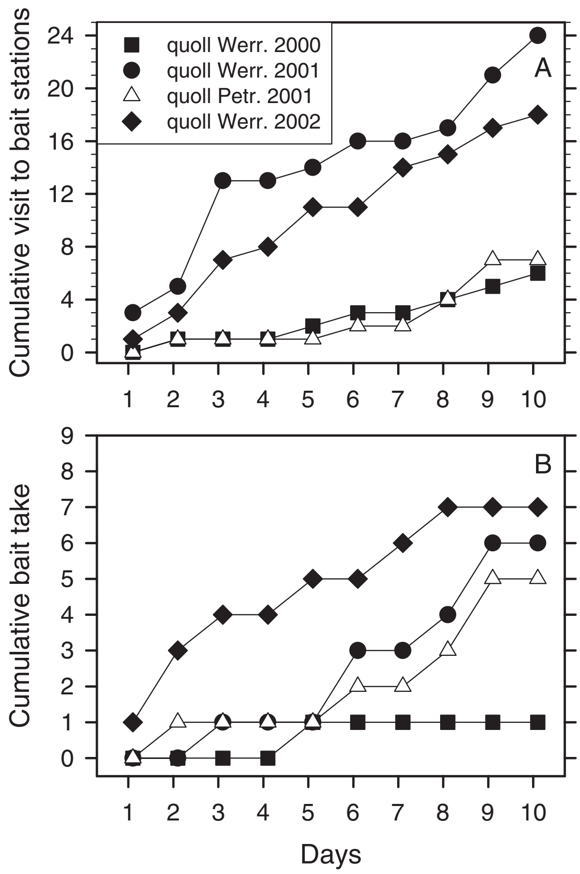

Fig. 2. Cumulative visits to bait stations (*A*) and bait takes (*B*) by quolls during four experimental baiting trails.

Visits to bait stations and bait removal by spotted-tailed quolls occurred regularly and the rates of visits and bait removals remained unchanged over the course of the baiting (Fig. 2). They removed the bait on about one-third of all visits (20 of 55) (Fig. 3). However, all but one of these baits were found in the vicinity of the bait station, having been discarded either on the bait station itself or in the surrounding bush up to 30 m from the bait station. There were often tooth marks in the bait and sometimes small pieces had been bitten off. The only bait not retrieved was during the first experiment, before we began to search intensively for baits moved away from bait stations. None of the quolls trapped after the baiting periods had traces of Rhodamine B in its vibrissae.

Foxes showed the highest level of bait acceptance, as more than 80% of recorded visits to bait stations by foxes resulted in bait removal (Fig. 3). However, the number of baits actually consumed remains unknown. At several bait stations baits were removed by foxes for many consecutive days, suggesting that these baits were being cached; one had been reburied at the edge of the bait station. In contrast, bait

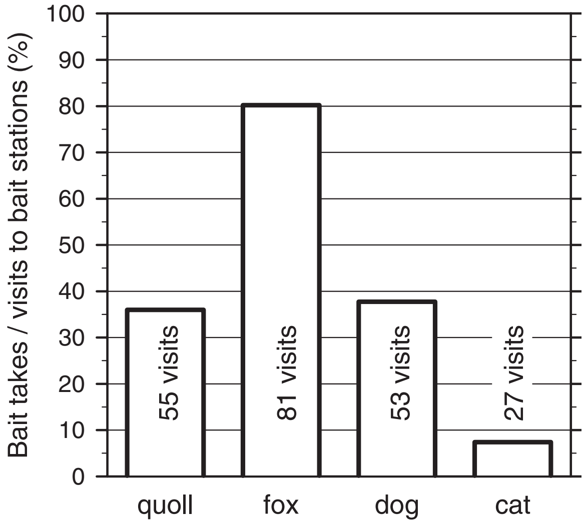

Fig. 3. Proportion of baits removed after visits to a bait stations.

ingestion at the station was only occasionally suspected due to small crumbles of bait remaining. Nevertheless, during the two autumn experiments in Werrikimbe NP (second and fourth experiment), when fox visits were common, the number of bait takes (the no. of visits also for the fourth experiment) appeared to decrease over the course of the 10-day baiting period (Fig. 4). Foxes were apparently less common at Petroi and no bait takes were recorded (see also track pads).

Bait takes by dogs occurred regularly only during the two autumn experiments in Werrikimbe NP (second and fourth experiment). Although no concerted effort was made to find baits removed by dogs, baits were occasionally found close by, unlike those taken by foxes. It is therefore possible that bait rejection by dogs occurred regularly. No takes were recorded during the first experiment and only two baits were taken from adjacent bait stations, probably by the same juvenile dog during the third experiment (footprints were traced and compared).

Cats did visit bait stations, but only two baits were removed (<10% of all visits) and at least one of these had been discarded nearby.

Bait take by small mammals, predominantly bush rats (*Rattus fuscipes*), but also *Antechinus* spp., occurred frequently, particularly during the experiments at Werrikimbe NP (Fig. 1). Baits that were found were partly eaten. Even if some individuals received a lethal dose of 1080, the baits were spaced too widely to affect the populations of either species.

Although bandicoots (primarily northern brown bandicoots, *Isodoon macrourus*) visited bait stations regularly during all four experiments they were responsible for less than 4% of bait takes (Fig. 1). Only during the last experiment did bandicoots remove baits, with five of the six

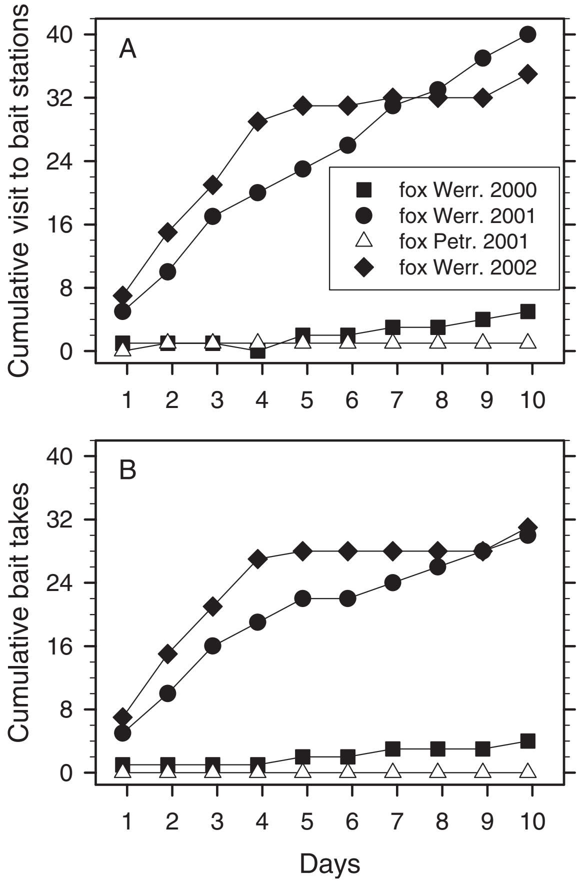

Fig. 4. Cumulative visits to bait stations (*A*) and bait takes (*B*) by foxes during four experimental baiting trails.

baits taken being found mostly intact near the bait station. Even if the remaining bait had been consumed entirely, the bandicoot should have survived the ingestion of 3 mg 1080 (McIlroy 1983).

Quoll mortality

Eighteen radio-collared quolls died over the course of the study of a variety of causes (Fig. 5). Fourteen of these died in the weeks proceeding the baiting periods and only one during a baiting period. In the latter case, no baits had been removed close to the quoll’s ‘home range’ and the quoll had been partly eaten by a fox. No traces of Rhodamine B were found in the mouth, nor was 1080 in the remaining tissue.

A further three animals died within a few weeks of the end of a baiting period when baits cached by canids or removed by small mammals could have still been toxic. One animal showed injuries consistent with a collision with a vehicle and a second (assayed for 1080) died of hypothermia, possibly caused by a spreading round-worm infestation. Neither had traces of Rhodamine B in mouth, gut or vibrissae and no 1080 was found in the assayed carcass. Hence, there was no evidence that they had come into contact with Foxoff® baits.

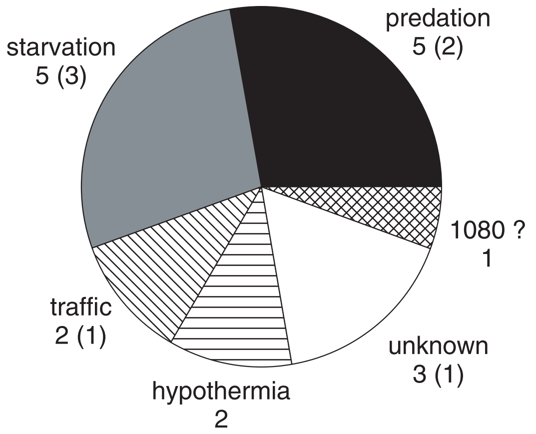

Fig. 5. Likely causes for the recorded 18 quoll mortalities. Numbers for animals less than one year old are given in parentheses.

However, Rhodamine B was found in the papilla of five whiskers of the third animal. This male (~2.3 kg) was found about two months after the end of the baiting period of the last experiment. The post-mortem suggested that death had occurred 1–2 weeks previously. The location of the fluorescent band indicated that Rhodamine B had been ingested less than two weeks before death, but the quoll must have survived for at least some days for the Rhodamine B to be incorporated into the vibrissae. No 1080 residues were detected in the carcass. Collectively, these data suggest that the quoll ate a cached bait 5–6 weeks after the end of the baiting. This bait was probably one of six baits (5 toxic) that had been removed from that area by foxes or dogs (all baits removed by quolls and, in this area, by small mammals had been found).

Overall, predation and starvation appeared to be the predominant causes of mortality (Fig. 5). Two adult female quolls were eaten, and possibly killed, by foxes (fox scats and strong scent nearby). The body of the individual found dead during the third experiment (adult male ~4 kg) was mummified, but the damage to the radio-collar suggested a fight with a large predator, probably a dog (the brass collar was severed and death must have been instantaneous because the collar was still around the neck). The remaining two kills were possibly caused by other quolls. This assumption is based on circumstantial evidence (an adult male quoll was present at the location of a wallaby carcass where a partly eaten juvenile was found the next day) and bite marks found on carcasses and radio-collars. Injuries were observed frequently, particularly on captured males. For example, one male quoll, which died from hypothermia, had a severe, debilitating leg injury and several quolls, including some females, had to be treated by a veterinarian for what appeared to be fighting injuries.

Predator tracks

Quoll tracks were encountered at an average rate of 2.7 ± 0.7 crossings per day and did not change significantly between pre- and post-baiting measurements (Table 2).

Table 2. Track pad counts
Cumulative track counts (number of crossings) for 4 nights before and after baiting. *G*-statistics with Yates' correction for continuity, d.f. = 1 (Zar 1996)

Species	Experiment	No pads	Total counts Before	Total counts After	Adjusted G_c	Significance
Quoll	Werrikimbe 2000	34[A]	8	18	2.853	n.s.
	Werrikimbe 2001	25	5	8	0.309	n.s.
	Petroi 2001	21	8	14	1.146	n.s.
	Werrikimbe 2002	26	17	7	2.841	n.s.
Fox	Werrikimbe 2000	34[A]	60	11	37.354	$P < 0.001$
	Werrikimbe 2001	25	25	22	0.085	n.s.
	Petroi 2001	21	1	0	0.000	n.s.
	Werrikimbe 2002	26	32	47	2.494	n.s.
Dog	Werrikimbe 2000	34[A]	9	2	3.687	n.s.
	Werrikimbe 2001	25	41	27	2.501	n.s.
	Petroi 2001	21	0	3	1.456	n.s.
	Werrikimbe 2002	26	4	27	17.293	$P < 0.001$
Cat	Werrikimbe 2000	34[A]	16	41	9.584	$P < 0.005$
	Werrikimbe 2001	25	13	26	3.753	n.s.
	Petroi 2001	21	6	21	7.626	$P < 0.01$
	Werrikimbe 2002	26	24	16	1.232	n.s.

[A]Five pads were unreadable for one night before baiting.

Track counts suggested that foxes were reasonably common in the Werrikimbe NP and Doyles River SF area, corroborating with bait take results (Table 2). During the first experiment fox track counts had decreased significantly after the baiting, but foxes remained present during and after the baiting had ceased. During the second and fourth experiment at that location track counts for foxes did not decline after baiting. The low number of tracks recorded during the third experiment at Petroi precluded any meaningful analyses (Table 2).

Day-to-day variations in dog track counts were pronounced and often one or a few individuals would cross many adjacent track pads. This compromised the usefulness of track pads for assessing dog populations, as for this larger species adjacent track pads were less independent than for the smaller species (Engeman *et al.* 1998). Nevertheless, the track counts suggested that fox baiting had a negligible impact on dog populations (Table 2).

The number of cat tracks increased significantly after baiting during two out of four experiments. However, as for dogs, counts for cats varied substantially between days, compromising the reliability of the results.

Discussion

Spotted-tailed quoll

The number of individual quolls trapped during these four experiments confirms that spotted-tailed quolls remain locally abundant in the north-east of New South Wales. However, overall, this species has suffered a marked reduction in its distribution and abundance since European settlement (Mansergh 1984) and it is thought that baiting programs against canids have contributed to this decline (Edgar and Belcher 1995; Belcher 1998). This assumption has recently attracted a lot of attention, because of the mounting interest in escalating fox baiting in conservation areas to protect species potentially threatened by fox predation (NPWS 2001).

The four experiments confirmed that quolls regularly remove Foxoff® baits (Belcher 1998), but they rarely eat them. Bait removal and bait consumption by quolls are clearly not equivalent. Consequently, the impact of baiting cannot be assessed by measuring bait removal alone, for example, by using track pads around bait stations or automatic cameras (Belcher 1998; Glen 2001). While quolls discarded at least 19 of the 20 removed baits, the only known bait consumption was the cached bait eaten some six weeks after baiting had ceased by a two-year-old male quoll that was found dead. It is uncertain whether this quoll died of 1080 poisoning, but, if so, then this was the only 1080-associated mortality observed during the four experiments.

Why most quolls did not eat the Foxoff® baits is unclear. They were unlikely to have developed bait shyness against Foxoff® because prior to our experiments neither this bait type nor mound baiting had been used in either study area. Another possibility was that the 1080 renders bait less palatable to quolls, as it does in dunnarts and some rodents (Sinclair and Bird 1984; Calver *et al.* 1989). A developed aversion against 1080 because of previous bait exposure (meat baits) would also have been possible. However, quolls discarded baits during the third experiment at Petroi where 1080 had never been used, and both toxic and non-toxic baits were equally rejected in the fourth experiment, refuting both possibilities. Similarly, aversion against the bait marker, Rhodamine B, at the dose used has never been observed in quolls or any other species tested (Fisher 1998; D. Fairbridge, DNRE Victoria, personal communication). Therefore, the most likely explanation is that the Foxoff® bait matrix is unpalatable to wild quolls.

It is likely that to a certain extent the palatability of a food source is influenced by the hunger status of an animal, which might change with season. However, baits were rejected at both sites and both seasons. Circumstantial evidence also suggested that natural food resources were never super-abundant. Several quolls apparently died of starvation, vertebra and ribs were often protruding noticeably in captured quolls, and quolls that had to be treated in captivity generally showed substantial and rapid weight gain. Furthermore, in captivity, where presumably food is provided in sufficient quantities, quolls have been observed eating non-toxic Foxoff® baits (Belcher 1998). It is therefore unlikely that this disparity between wild and captive quolls is caused by differences in the hunger status.

For two other quoll species, the northern quoll (*D. hallucatus*) and the western quoll (*D. geoffroii*), bait consumption in captivity also suggested high risks during fox-control operations (Calver *et al.* 1989; Soderquist and Serena 1993; Martin *et al.* 2002). As is the case with spotted-tailed quolls, field experiments using toxic baits in conjunction with mortality transmitters failed to confirm this assumption. The first experiment assessed the impact of aerial dog baiting with sun-dried meat baits on northern quolls (King 1989), while the other investigated the fate of western quolls in areas subjected to extensive aerial fox baiting with dried meat bait (Morris *et al.* 1995). In neither case was any 1080-related mortality detected, and in the latter study the quoll population apparently increased, probably due to the removal of foxes. Unfortunately, in both studies bait consumption could not be monitored, so the lack of mortality remains unexplained, but it is known that drying reduces the palatability of meat baits for quolls (Soderquist and Serena 1993; Martin *et al.* 2002). However, differences in bait consumption between captive and free-ranging animals apparently also exist for softer bait types such as Foxoff® (Belcher 1998; this study) and these might well be related to behavioural differences, such as familiarity to different food types.

Foxes

Since fox numbers were very low at Petroi only the three experiments conducted in Werrikimbe NP warranted analysis. The first experiment was conducted in spring before young foxes are independent. While few baits were taken, the decrease in track counts after baiting suggested a significant impact on the probably small resident fox population (Table 2). The two other experiments were conducted in late autumn when young foxes disperse (Phillips *et al.* 1972). Bait takes were considerably higher, although initial high values may have been inflated by foxes caching baits (Saunders *et al.* 1999; von Polanen Petel *et al.* 2001), and decreased over the 10 days of baiting. While the latter may suggest fox mortalities, this was not supported by significant declines in the number of fox tracks (Table 2). Usually, most foxes succumb in the first days of baiting, but it can take more than a month before the last animals die (Dexter and Meek 1998; Thomson *et al.* 2000). Thus, fox numbers may have decreased if the baiting had been extended. Whatever the reason, at least during two experiments 10 days of baiting did not result in a substantial decrease in the fox population.

Other eutherian carnivores

Fox baiting had little effect on other eutherian carnivores. No dog visits to bait stations were recorded during the first experiment and there were only two dog takes (probably by the same dog) during the third experiment. Only during the two autumn experiments in Werrikimbe did dogs visit bait stations regularly, but bait acceptance was lower than for foxes and bait rejection was common. In neither case did track counts substantiate a significant decrease in dog numbers. The significant increase in dog tracks after the baiting during the third Werrikimbe experiment was interesting. Initial neophobia to track pads is a possible explanation, but a litter of newborn pups was found only a few hundred metres off the road during the baiting period, so some dogs may have changed their movement patterns between the two counts.

Cats were occasionally sighted and sometimes trapped. The track counts confirmed that they were common at both study areas. With only two bait removals and, at most, one bait consumption Foxoff® is clearly not a suitable bait type for controlling cats. In fact, cat track counts increased significantly twice after baiting. While there is some evidence that fox control can lead to an increase in cat numbers (Risbey *et al.* 2000), this was unlikely to be a contributing factor over the short period between the counts.

Conclusion

In conclusion, our project has been the first to directly assess the risk of 1080 fox baiting to free-ranging spotted-tailed quolls. Fox baiting using Foxoff® baits had at most a very marginal impact on spotted-tailed quoll populations, causing less mortality amongst radio-collared quolls than fights between quolls or with other carnivores. This was most likely because wild spotted-tailed quolls find Foxoff® baits unpalatable. We then suggest that bait stations frequented by quolls can be baited with Foxoff®, thereby avoiding the current labour-intensive preliminary free-feeding and daily monitoring of bait stations. However, baits should still be buried to reduce bait take by birds, small mammals and quolls (Allen *et al.* 1989; Belcher 1998; Glen 2001), consequently increasing the number of baits available to foxes.

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