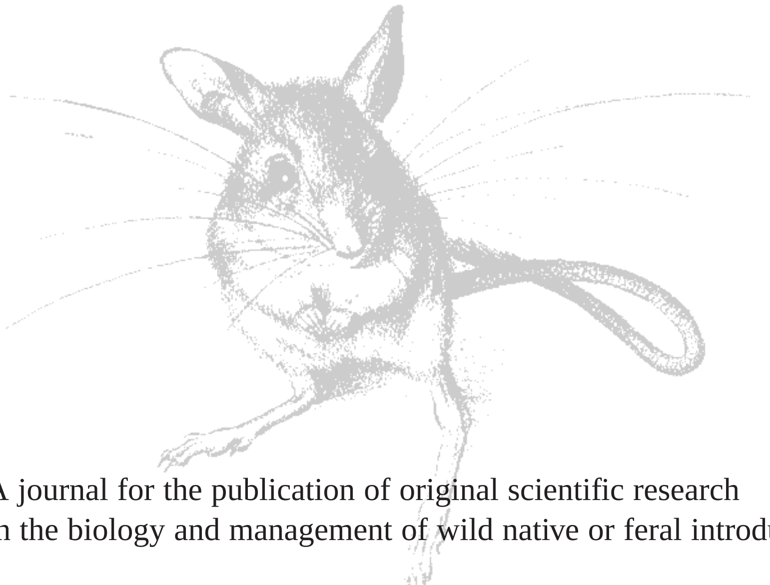
CSIRO PUBLISHING

Wildlife Research

Volume 25, 1998



A journal for the publication of original scientific research
in the biology and management of wild native or feral introduced vertebrates

www.publish.csiro.au/journals/wr

All enquiries and manuscripts should be directed to
Wildlife Research
CSIRO PUBLISHING
PO Box 1139 (150 Oxford St)
Collingwood
Vic. 3066
Australia

Telephone: 61 3 9662 7622
Facsimile: 61 3 9662 7611
Email: david.morton@publish.csiro.au

CSIRO AUSTRALIA

Published by **CSIRO** PUBLISHING
for CSIRO Australia and
the Australian Academy of Science

Academy of Science

 Wildlife Research, 1998, **25**, 33–40

Susceptibility of the tiger quoll, *Dasyurus maculatus*, and the eastern quoll, *D. viverrinus*, to 1080-poisoned baits in control programmes for vertebrate pests in eastern Australia

C. A. Belcher

Ecosystems Environmental Consultants, RMB 7285, Timboon, Vic. 3268, Australia.

Abstract

Captive trials were undertaken to determine whether tiger quolls and eastern quolls could detect baits that were either buried or covered with soil following the methods employed in normal buried-poisoned-bait programmes. Both tiger quolls and eastern quolls detected, dug up and consumed buried FOXOFF baits. Consumption trials showed that tiger quolls were capable of consuming 2–3 FOXOFF baits in a single meal and more than three baits overnight. Eastern quolls could consume up to 1.5 baits in a single meal.

Field trials were undertaken to investigate whether tiger quolls in the wild could also detect and consume buried baits. Trials with both fresh meat and FOXOFF baits were undertaken at a site near a tiger quoll latrine, using a remote camera to record visits to the site and bait uptake. The results confirmed that tiger quolls in the wild can detect and consume both fresh meat and FOXOFF baits that have been buried or placed on the surface and covered with soil to a depth of 5–8 cm.

The results indicate that the buried-bait technique is not specific for introduced predators, and free-feeding may not preclude non-target species from taking buried baits. Reliance on the identification of the species visiting bait stations from tracks may also be unreliable as foxes dug up bait stations searching for baits, even after the bait had been removed, potentially obliterating other tracks.

Introduction

Sodium monofluoroacetate or 1080 poison is widely used in Australia to control vertebrate pest species, such as wild dogs and dingoes (*Canis familiaris*), foxes (*Vulpes vulpes*), feral pigs (*Sus scrofa*), rabbits (*Oryctolagus cuniculus*), common brushtail possums (*Trichosurus vulpecula*), Bennett’s wallabies (*Macropus rufogriseus*) and rufous wallabies (*Thylogale billardierii*) (McIlroy 1982; King *et al*. 1989; Calver *et al*. 1989; Thompson 1995).

Concern has been raised about the specificity of 1080 and its impact on non-target native species, including the risk of secondary poisoning (McIlroy 1981*a*; Twigg 1986; Calver *et al*. 1989; King 1989; King *et al*. 1989). This applies especially to native carnivores such as the chuditch (*Dasyurus geoffroii*) and tiger quoll (*D. maculatus*) (Soderquist and Serena 1993; Watt 1993; Belcher 1994). The use of 1080 to control predators has been banned in the USA since 1972, because of insufficient data detailing impact on non-target species (Thompson 1995). There is a similar dearth of information on the potential impact of 1080 poisoning on non-target species in eastern Australia, with few field studies undertaken to determine the impact on such species, possibly because of the difficulties involved with studying species that are rare or occur at low densities (McIlroy 1981*a*; McIlroy 1982; Calver *et al*. 1989; King *et al*. 1989; Korn *et al*. 1992; Soderquist and Serena 1993; Belcher 1994; Thompson 1995). Circumstantial evidence indicates that buried-poisoned-bait programmes can have a significant impact on local tiger quoll populations (Belcher 1994).

The current methods of controlling introduced predators in Victoria, such as wild dogs, dingoes and foxes, involve trapping and poisoning. Baits used for control of wild dogs and dingoes are either fresh meat or cooked offal, such as liver, which may weigh up to 250 g (VerminPac 1988). Baits used and promoted by the Department of Natural Resources and

10.1071/WR95077 1035-3712/98/010033

Environment (DNRE) in Victoria for fox control are manufactured from fats, offal, cereal and 1080 poison (FOXOFF) and weigh approximately 60 g (VerminPac 1993). 1080 dose rates per bait in Victoria are 4.5 mg for dog baits and 3.3 mg for FOXOFF baits (VerminPac 1988, 1993). The current method promoted in Victoria by DNRE for using poisoned baits is to heap soil over each bait or to bury it to a depth of 5–8 cm (VerminPac 1993). Baits are generally placed along tracks or trails through bush or forested country.

As part of a larger study examining the sensitivity of Australian animals to 1080 poison, McIlroy (1981*b*) conducted LD_{50} (lethal dose for 50% of individuals) trials with marsupial and eutherian carnivores. He found that eutherian carnivores were more sensitive to 1080 poison than were marsupial carnivores, but with wide intra- and interspecific variations. McIlroy (1981*b*) also noted that ambient temperature may have a significant effect on the toxicity of 1080 poison. Further research is required into the effect of high and low temperatures on 1080 toxicity in quolls, as the toxicity of 1080 is known to increase substantially in mice (*Mus musculus*), guinea-pigs (*Cavia porcellus*) and brushtail possums at ambient temperatures below 13 and above 30°C (Oliver and King 1983).

The LD_{100} (lethal dose for 100% of individuals) for the tiger quoll to 1080 poison, current 1080 dose levels and the range of body weights in a tiger quoll population would suggest that tiger quolls are at risk from 1080 poison baiting. McIlroy (1981*b*) suggests an LD_{100} of 2.56 mg kg^{-1} for tiger quolls. The 1080 dose levels for baits range from 3.3 to 6.0 mg (Thompson 1995). Tiger quoll body weights range from approximately 350 g for newly independent young (C. Belcher, unpublished data; R. Warneke, personal communication) up to approximately 4.5 kg. Tiger quolls do not reach maximum weight until their third year (C. Belcher, unpublished data), and the species is sexually dimorphic for weight, with males almost twice the weight of females (Settle 1978; Green and Scarborough 1990). Consumption of a single bait would therefore provide a lethal dose of 1080 for all juvenile, most female and a proportion of adult male tiger quolls.

Similarly, a proportion of a population of eastern quolls, particularly juveniles and females, is likely to receive a lethal dose from ingesting one bait. The eastern quoll is also sexually dimorphic for weight. Average weights for eastern quolls are 400 g for newly weaned young, 850 g for first-year females and 1.3 kg for first-year males (Merchant *et al*. 1984; Bryant 1988*a*, 1988*b*). Eastern quolls have an LD_{50} of between 1.5 (King *et al*. 1989) and 3.73 mg kg^{-1} (McIlroy 1981*b*).

Tiger quolls may also be at risk from secondary poisoning. Captive and wild tiger quolls have been recorded consuming entire adult rabbits (Troughton 1954; R. Warneke, personal communication); most tiger quolls would receive a lethal dose from consuming a 1080-poisoned rabbit, on the basis of the average 1080 residue level recorded in rabbits by McIlroy and Gifford (1992).

No captive or field trials have previously been undertaken to assess the risk to, or susceptibility of, the tiger quoll to the current 1080-poisoned-bait methods. This paper reports on the results of such bait trials and examines the adequacy of existing baiting prescriptions with regard to the tiger and eastern quolls.

Methods

Buried-bait Trials on Captive Animals

Non-poisoned FOXOFF baits were presented to captive tiger quolls and eastern quolls at the Healesville Sanctuary, Healesville, Victoria, from 16 July 1993 to 22 April 1994. One female and two male tiger quolls, occupying separate pens, and two eastern quolls sharing one pen were used in the trial. The outdoor enclosures in which the female tiger quoll and the two eastern quolls were kept measured 2 × 5 × 3 m high. The male tiger quolls were tested in an outdoor enclosure measuring 4 × 5 × 3 m high, which they occupied alternately.

All three tiger quolls were born in captivity and were three years old at the commencement of the bait trial. Because of a dermal infection, one male was isolated from the other quolls until the infection was cured and hence it was tested in February and March 1994.

The female tiger quoll was filmed with an infrared videocamera during each trial.

Each trial ran for three days. In the first trial, to determine whether quolls would investigate disturbed soil simulating a bait site, four holes were excavated in each pen to a depth of 20 cm and then filled in without bait being placed in them. In subsequent trials, a bait was placed in one of four new holes, chosen at random, between 1430 and 1500 hours. Baits were placed in holes out of sight of the quolls, which were in their nest boxes. The depth at which the bait was buried was decreased from 20 to 10 to 5 cm with each successive trial (the bait being removed at the end of each trial if not eaten and a new bait placed in a new hole) until a bait was found by an animal. The trial was then repeated four times at intervals of at least one day, with the bait buried at the depth at which the bait had first been discovered, to determine the proportion of baits detected at that depth. This procedure was repeated until the animal found 100% of the baits at a given depth.

The male eastern quoll was born in the wild in Tasmania and was of unknown age. The captive-born female was nearly three years old at the commencement of the trials.

The animals were routinely fed six mornings per week at approximately 0800 hours and fasted on the seventh day. During the bait trials the animals were fed between 1630 and 1700 hours, except on the first day of each trial, which coincided with their starve day. The animals' captive diet contained a mixture of foods that was designed to represent the species' natural diet.

Consumption Trials

Consumption trials were carried out in April 1994. Quolls were presented with three non-poisoned FOXOFF baits instead of their normal ration at their usual feeding time, and the weight of baits eaten immediately was recorded. Baits eaten were replaced and the total amount of bait consumed overnight was recorded the following morning.

Buried-bait Trials in the Field

Field trials were conducted between May 1994 and January 1995 at Suggan Buggan, East Gippsland, near an active tiger quoll latrine (Belcher 1995), with non-poisoned baits. Seven fresh meat baits, consisting of approximately 250 g of either beef or rabbit, and seven FOXOFF baits were covered with soil to a depth of approximately 7.5 cm. Bait take was monitored with a Canon Sureshot Supreme camera with a heat-sensor shutter trigger and by examining tracks at the bait mound sites, which were raked to enable footprints to be observed. Baits and film were replaced every 3–4 weeks.

In order to assess bait acceptance and specificity, free-feed trials with non-poisoned baits to simulate normal baiting programmes have been conducted (Applied Biotechnologies). A free-feed trial was conducted at Suggan Buggan to assess potential impact on the local tiger quoll population, by Applied Biotechnologies and DNRE between 3 and 17 June 1994 (S. McPhee, Applied Biotechnologies, personal communication). A total of 131 bait stations was established along a number of tracks in the Suggan Buggan area. In order to assess the techniques used by Applied Biotechnologies and DNRE, five of the bait stations were monitored after the trial by raking the sand at each station for four mornings, without bait being placed in them. Each station was then monitored for four days and species visiting the bait stations were identified from the tracks on the raked sand.

Results

Buried-bait Trials on Captive Animals

The tiger quolls investigated two holes (to a depth of 1.5 and 2.5 cm) during the initial trial. Only holes containing bait or holes that had previously contained bait were investigated during subsequent trials (Table 1*a–c*). In those trials in which the buried bait was found, the tiger quoll went immediately to the hole containing the bait, dug it up and ate it. One male tiger quoll dug an old bait hole to 12 cm immediately after a partially disintegrated bait had been removed, leaving traces of bait in the soil (Table 1*b*).

The eastern quolls dug one hole to a depth of 6 cm in the first trial and found and ate all four baits buried at the maximum depth of 20 cm on the first night of each trial (Table 1*d*).

Consumption Trials

The three tiger quolls all ate at least one bait immediately and 2–3 baits overnight. The male eastern quoll consumed approximately 1.5 baits while the female consumed approximately $\frac{1}{3}$ of a bait at the commencement of the trial. Consumption did not increase substantially overnight (Table 2).

Table 1. Results from buried-bait trials with tiger and eastern quolls at Healesville Sanctuary

Trial	Position of bait	Depth of bait (cm)	Depth of hole dug (cm) Position 1	Position 2	Position 3	Position 4	Bait taken
			(a) Female tiger quoll, July–September 1993				
1	No bait		–	–	–	2.5	No
2	3	20	–	–	–	3	No
3	4	10	–	–	6	10	Yes
4	1	10	10	–	–	–	Yes
5	2	10	–	10	–	–	Yes
6	3	10	–	–	10	–	Yes
			(b) First male tiger quoll, July–September 1993				
1	No bait		–	–	–	1.5	No
2	4	20	–	–	2	–	No
3	2	10	–	–	–	–	No
4	3	5	–	–	–	–	No
5	1	5[A]	5	–	–	–	Yes
			(*c*) Second male tiger quoll, February–April 1994				
1	No bait		–	–	–	–	No
2	2	20	–	–	–	–	No
3	4	10	–	–	–	–	No
4	3	5	–	–	–	–	No
5	1	5[A]	5	–	–	–	Yes
			(d) Two eastern quolls, July–September 1993				
1	No bait		–	–	–	6	No
2	2	20	–	20	–	–	Yes
3	4	20	–	–	–	20	Yes
4	3	20	–	–	20	–	Yes
5	1	20	20	–	–	–	Yes

[A]Left on the surface but covered with soil to a depth of approximately 5 cm.

Table 2. FOXOFF bait-consumption trials at Healesville Sanctuary
Each bait weighed 55 g on average

Individual	Weight (g) of bait eaten after 1 h	Weight (g) of bait eaten after 15 h
First male tiger quoll	150	180
Second male tiger quoll	75	120
Female tiger quoll	55	155
Male eastern quoll	80	80
Female eastern quoll	15	15

Field Buried-bait Trials

Seven of 14 buried baits were taken during the trial. Two individual tiger quolls (one male, one female) were filmed digging up baits. Seven baits were taken at the site until a bushfire burned the site in September. Tiger quoll visits to the site ceased after the fire, as did the taking of bait. The remote camera did not operate during daylight, and consequently failed to detect the taking of five baits.

No tracks were recorded at the bait mound during the study.

Bait-station Monitoring

On each day, at least three of the five bait stations were visited by a fox or foxes with extensive digging taking place. On three of the four days, four bait stations were visited and dug by foxes. Because of the extent of digging, it was not possible to determine whether other species had also visited.

Discussion

Captive Trials

In captivity, tiger and eastern quolls are capable of detecting, digging up and consuming FOXOFF baits that have been buried at depths greater than those recommended by State agencies. As wild tiger quolls and eastern quolls are probably more alert and more motivated by hunger than are captive specimens, it is reasonable to assume that the results of the trials provide a conservative indication of the capabilities of these two species to locate buried food. The results refute the assumption that tiger quolls and eastern quolls are incapable of detecting and digging for buried baits, which has been the basis for the policy of burying or covering poisoned baits. It follows that the tiger quoll and eastern quoll are at risk when predator control is conducted in quoll habitat using the current methods of burying 1080-poisoned baits.

The behaviour of the tiger quolls and eastern quolls in captivity was closely monitored, as it was anticipated that any unusual disturbance in their enclosures, to which they were thoroughly familiarised, would stimulate investigation. The results indicate that soil disturbance was detected by the animals. Soil disturbance did not provide sufficient stimulus for tiger quolls to dig deeper than 3 cm and for eastern quolls to dig deeper than 6 cm. Not all holes were investigated by digging, indicating that the animals were not simply reacting to sites of soil disturbance in their pens. The eastern quoll has been recorded taking large numbers of pasture grubs in the wild (Blackhall 1980; Godsell 1982) and may thus be better adapted to detecting and digging for buried food than is the tiger quoll.

The likelihood of encountering baits is much higher in captivity, because of the small size of the enclosures, than in the wild. Without knowing the home-range size and normal daily movement patterns of the tiger quoll in the wild and the relative densities, movement patterns and behavioural dynamics of sympatric introduced predators, little can be inferred from the captive trials of the comparative likelihood of encountering baits in the wild.

Similarly, while this study shows that some captive tiger quolls can detect buried baits and will dig them up and eat them, it does not provide insight into the variability that probably exists in the capacity of this species to detect and dig up buried baits designed to attract carnivores in the wild.

Consumption Trials

The ability of captive tiger quolls to consume up to three baits in one meal and more than three baits overnight suggests that wild tiger quolls are capable of ingesting at least three baits per night. Three baits will provide a lethal dose for all tiger quolls up to a weight of 3.5 kg, half of the tiger quolls weighing between 3.5 and 5.3 kg and a proportion of tiger quolls weighing between 5.3 and 7.7 kg at temperatures between 13 and 30°C (McIlroy 1981*b*). Hence, the results of this trial indicate that bait placement may be an important component of poisoned-bait programmes. If baits are placed too close together, it would be possible for tiger quolls to find and consume a number of baits, increasing the potential of ingesting a lethal dose of 1080 poison.

Field Buried-bait Trials

The results of the buried-bait trials near the Mt Stradbroke tiger quoll latrine confirm that wild tiger quolls detect, dig up and consume buried meat and FOXOFF baits covered to a depth of approximately 7.5 cm. The remote camera did not operate in daylight and it failed to record the taking of five baits. Previous monitoring at the latrine site revealed substantial tiger quoll activity before dusk and after dawn (Belcher 1994). No foxes or dogs were recorded at the site, nor were fox or dog scats observed at or in the vicinity of the latrine. The removal of five baits not recorded by the camera is therefore suspected to have been entirely by tiger quolls.

The results of this trial are supported by the findings from the free-feed trial at Suggan Buggan (S. McPhee, personal communication) and from a baiting programme to protect a colony of brush-tailed rock wallabies (*Petrogale penicillata*) near Nowra in New South Wales (L. Dovey, personal communication).

The results of the free-feed bait trial undertaken at Suggan Buggan (S. McPhee, personal communication) also confirm that tiger quolls will take buried baits during a normal bait programme and that even when foxes are abundant, tiger quolls are put at risk by poison baiting. The taking of baits by tiger quolls was inferred from tracks and hairs left in hairtubes adjacent to the bait stations (S. McPhee, personal communication) and from the presence of coloured plastic marker beads in a tiger quoll scat collected after the trial (C. Belcher, unpublished data). Coloured plastic marker beads were used in the free-feed baits to distinguish between fresh meat and FOXOFF baits. However, the results of these trials probably underestimate the actual risk to tiger quolls during a normal poisoned-bait programme, as progressively more baits would become available to them as the number of foxes taking baits is reduced. One of the baits believed to have been taken by a tiger quoll was at a bait station that had previously been visited on one occasion by a fox (S.McPhee, personal communication), which raises concern about the effectiveness of monitored free feeding prior to poisoning to ensure that non-target species are not present. The free-feed period may need to be more generous, and be monitored daily to be effective.

In 1492 free-feed bait-nights during a predator-control programme to protect a colony of brush-tailed rock wallabies in southern New South Wales, a large number of non-target species was recorded, including 26 instances of tiger quolls taking baits (L. Dovey, New South Wales National Parks and Wildlife Service, personal communication). Baiting techniques differed from those used elsewhere, in that each bait station was checked daily, free-feed baits were used extensively and sites where non-target species were detected were not poisoned (L. Dovey, personal communication).

Monitoring of five bait stations after the completion of the free-feed trial revealed that most of the bait stations had been dug up by foxes, even though no baits were present. Of particular concern was the obliteration of tracks by the extensive digging by foxes searching for bait. Given that foxes will dig at bait stations even after the bait has been removed, the presence of other species and particularly the removal of bait by non-target species can easily be obscured. This behaviour needs to be taken into consideration when interpreting the results of free-feed bait trials, which rely on recording tracks at bait stations to determine the species responsible for taking bait. These trials also depend on observers being able to identify non-target species' tracks, as well as daily monitoring of bait stations and fine weather, because rainfall, snowfall and frosts can obliterate or obscure animal tracks (McIlroy *et al*. 1986).

Conclusion

The current buried-bait techniques are not specific for introduced predators, because tiger quolls were found to detect, dig up and consume fresh meat and FOXOFF baits that had been buried to depths of up to 10 cm, and eastern quolls were found to be able to detect, dig up and consume baits buried to a depth of 20 cm. Both species are sexually dimorphic for weight, with juvenile and female tiger quolls and eastern quolls particularly at risk because they could receive a lethal dose from ingesting one 1080 bait at the dose rates currently used. The widespread use of 1080 poison baits for control of wild dogs and foxes may be contributing to the tiger quoll's continuing decline and may preclude a successful reintroduction of the eastern quoll on the mainland.

Acknowledgments

This study was funded by the Australian Nature Conservation Agency (ANCA) under the Feral Pest Programme. The following people are gratefully acknowledged for their assistance with this study: Jim Barrett and the FPP staff at ANCA; Brian Phillips and the keepers at Healesville Sanctuary; Dr Mike Clarke (LaTrobe University) and Bob Warneke, who supervised the captive trial study and who with Dr Barb Wilson (Deakin University) provided valuable suggestions on an earlier draft; Andrew Murray (DNRE, Orbost), who provided some field support. Particular thanks are due to Bob Warneke for his editorial effort on a later draft and for supplying information on the tiger quolls that he and Ann Troy have held in captivity. Applied Biotechnologies supplied the free-feed FOXOFF baits.

References

Belcher, C. A. (1994). Studies on the diet of the tiger quoll *Dasyurus maculatus*. M.Sc. Thesis, LaTrobe University, Melbourne.

Belcher, C. A. (1995). Diet of the tiger quoll (*Dasyurus maculatus*) in East Gippsland, Victoria. *Wildlife Research* **22**, 341–357.

Blackhall, S. (1980). Diet of the eastern native-cat, *Dasyurus viverrinus* (Shaw), in southern Tasmania. *Australian Wildlife Research* **7**, 191–197.

Bryant, S. L. (1988*a*). Seasonal breeding in the eastern quoll *Dasyurus viverrinus* (Marsupialia : Dasyuridae). Ph.D. Thesis, University of Tasmania, Hobart.

Bryant, S. L. (1988*b*). Maintenance and captive breeding of the eastern quoll. *International Yearbook* **27**, 119–124.

Calver, M. C., McIlroy, J. C., King, D. R., Bradley, J. S., and Gardner, J. L. (1989). Assessment of the approximate lethal dose technique for determining the relative susceptibility of non-target species to 1080 toxin. *Australian Wildlife Research* **16**, 33–40.

Godsell, J. (1982). Aspects of the population ecology of the eastern quoll, *Dasyurus viverrinus* (Dasyuridae, Marsupialia) in southern Tasmania. In 'Carnivorous Marsupials'. (Ed. M. Archer.) pp. 199–207. (Royal Zoological Society of New South Wales: Sydney.)

Green, R. H., and Scarborough, T. J. (1990). The spotted-tailed quoll, *Dasyurus maculatus* (Dasyuridae, Marsupialia) in Tasmania. *Tasmanian Naturalist* **100**, 1–15.

King, D. R. (1989). An assessment of the hazard posed to northern quolls (*Dasyurus hallucatus*) by aerial baiting with 1080 to control dingoes. *Australian Wildlife Research* **16**, 569–574.

King, D. R., Twigg, L. E., and Gardner, J. L. (1989). Tolerance to sodium monoflouroacetate in dasyurids from Western Australia. *Australian Wildlife Research* **16**, 131–140.

Korn, T., Fosdick, M., Lukins, B., Wiseman, G., Meany, J., Barnes, T., and Kay, B. (1992). Fauna Impact Statement. Endangered Fauna (Interim Protection) Act 1991. The impact of vertebrate pest control on endangered fauna in New South Wales. New South Wales Department of Agriculture, Orange.

McIlroy, J. C. (1981*a*). The sensitivity of Australian animals to 1080 poison. I. Intraspecific variation and factors affecting acute toxicity. *Australian Wildlife Research* **8**, 369–383.

McIlroy, J. C. (1981*b*). The sensitivity of Australian animals to 1080 poison. II. Marsupial and eutherian carnivores. *Australian Wildlife Research* **8**, 385–399.

McIlroy, J. C. (1982). The sensitivity of Australian carnivorous marsupials to 1080 poison. In 'Carnivorous Marsupials'. (Ed. M. Archer.) pp. 267–271. (Royal Zoological Society of New South Wales: Sydney.)

McIlroy, J. C., and Gifford, E. J. (1992). Secondary poisoning hazards associated with 1080-treated carrot-baiting campaigns against rabbits, *Oryctolagus cuniculus*. *Wildlife Research* **19**, 629–641.

McIlroy, J. C., Cooper, R. J., Gifford, E. J., Green, B. F., and Newgrain, K. W. (1986). The effect on wild dogs, *Canis f. familiaris*, of 1080-poisoning campaigns in Kosciusko National Park, N.S.W. *Australian Wildlife Research* **13**, 535–544.

Merchant, J. C., Newgrain, K., and Green, B. (1984). Growth of the eastern quoll, *Dasyurus viverrinus* (Shaw), (Marsupialia) in captivity. *Australian Wildlife Research* **11**, 21–29.

Oliver, A. J., and King, D. R. (1983). The influence of ambient temperatures on the susceptibility of mice, guinea-pigs and possums to compound 1080. *Australian Wildlife Research* **10**, 297–301.

Settle, G.A. (1978). The quiddity of tiger quolls. *Australian Natural History* **19**, 164–169.

Soderquist, T. R., and Serena, M. (1993). Predicted susceptibility of *Dasyurus geoffroii* to canid baiting programmes: variation due to sex, season and bait type. *Wildlife Research* **20**, 287–296.

Thompson, J. (1995). Review of 1080 use in Queensland. Land Protection Branch, Queensland Department of Lands.

Troughton, E. (1954). The marsupial tiger cat. Birth and growth in captivity. *Australian Museum Magazine* **11**, 200–202.

Twigg, L. E. (1986). The physiological, ecological and evolutionary significance of monofluoroacetic acid in relation to plant animal interactions in Australia. Ph.D. Thesis, Murdoch University, Perth.

VerminPac (1988). Prescriptions for the use of poison baits prepared by the Department of Conservation and Natural Resources, Victoria.

VerminPac (1993). Prescriptions for the use of poison baits prepared by the Department of Conservation and Natural Resources, Victoria.

Watt, A. (1993). Conservation status and draft management plan for *Dasyurus maculatus* and *D. hallucatus* in southern Queensland. Queensland Department of Environment and Heritage, Brisbane.

Manuscript received 21 November 1995; revised 5 March 1996; revised and accepted 9 May 1997