

The Ability of Spotted-tailed Quolls to Locate and Consume Meat Baits Deployed During a Simulated Aerial Baiting Program

Prepared For The

Australian Alps Liaison Committee

And

The New South Wales National Parks & Wildlife Service

A. J. Murray^{1*}, C. A. Belcher¹, R.N. Poore¹ and J. Darrant



East Gippsland Flora & Fauna Group Report No. 9

February 2000

¹ Victorian Department of Natural Resources &
ECOsystems Environmental Consultants

*Author to which all correspondence should be directed.

Contents

Executive Summary	3
Introduction.....	4
Materials & Methods	6
Introduction.....	6
Study Site	6
Bait Preparation	7
Bait Palatability.....	8
Baiting Methodology	8
Post-baiting Trapping.....	9
Analysis of the Vibrissae	10
Results.....	12
Post-baiting Trapping Results.....	12
Results of the Vibrissae Analysis	12
Discussion	13
Conclusions.....	17
Recommendations.....	18
Acknowledgments.....	19
References.....	20

Cover Photograph: A Spotted-tailed Quoll scat discovered on a latrine site in Tallaganda State Forest; the pink Rhodamine B dye can clearly be seen oozing onto the rock. This was one of six quoll scats found containing the dye (Photo: Andrew Murray)

Executive Summary

Spotted-tailed Quolls (*Dasyurus maculatus*) are marsupial carnivores that are confined to forested habitats in southeastern Australia and Tasmania. They are the largest extant dasyurid species on mainland Australia, and the only surviving species of *Dasyurus* in southeastern Australia.

"

Nationally, the conservation status of the Spotted-tailed Quoll is listed as "vulnerable". It is listed as "endangered" in Victoria, and "vulnerable and rare" in New South Wales. Threats to the species in the past have included widespread habitat removal (primarily for agriculture and pastoralism) and persecution by settlers (trapping, shooting and poisoning) due to the threat the species poses to poultry. An epidemic disease may have affected the species in the early part of the 20th century. Current threats to the species are thought to include habitat fragmentation and modification, and competition from introduced predators such as the Red Fox (*Vulpes vulpes*) and the Cat (*Felis catus*).

Poisoning programs to control Dingoes (*Canis lupus dingo*), feral dogs (*Canis familiaris*) (hereafter referred to inclusively as "wild dogs") and foxes are believed to be a potential threat to populations of the Spotted-tailed Quoll (Mansergh and Belcher 1992). One method of poisoning that potentially poses a significant risk is aerial baiting to reduce wild dog numbers, which takes place in some forested habitats in New South Wales. This form of bait deployment uses uncooked (air-dried) 250g kangaroo meat baits injected with the toxin 1080. Helicopters are used to distribute the baits. Baiting programs carried out by Rural Lands Protection Boards (RLPB) in southeast New South Wales adopt a bait distribution frequency of approximately 40 baits per kilometre of flight transect, whereas the NSW National Parks & Wildlife Service drop baits at a frequency of 10 baits per kilometre.

A simulated aerial baiting program was carried out in Tallaganda State Forest (southeastern New South Wales) in order to determine what percentage of a population of Spotted-tailed Quolls were able to locate and consume aeriually-deployed meat baits. The trial replicated a standard RLPB aerial baiting program except that the baits were injected with a non-toxic biomarker, a dye called Rhodamine B, rather than the toxin 1080.

Three weeks after bait distribution, a cage-trapping program targeting Spotted-tailed Quolls was undertaken in Tallaganda State Forest over a period of 12 days. Sixteen quolls were captured, sedated and had eight vibrissae (whiskers) removed for analysis. Rhodamine B is laid down in the follicles of hair, and is easiest seen and most consistently laid down in vibrissae. Under ultraviolet light the dye glows, therefore indicating that bait ingestion has taken place.

Analysis of the vibrissae indicated that 10 of the 16 quolls captured had consumed Rhodamine B-injected baits. Both male and female quolls had located and consumed baits, including three of the four females captured that had pouch young.

The result that over 60% of the sampled quoll population *were* able to locate and consume an aeriually-deployed meat bait in a single baiting operation suggests that aerial baiting at the intensity used during this trial in forested habitats may pose a serious risk to populations of this species.

The results suggest that land management agencies that employ aerial baiting in areas inhabited by Spotted-tailed Quolls should review their use of the method, and consider the use of techniques which reduce the risk of quolls locating and consuming *poison* baits.

Introduction

The Spotted-tailed Quoll, *Dasyurus maculatus*, is the last remaining quoll species extant in southeastern Australia. It is a forest-dependent carnivorous marsupial, and occupies a variety of forest habitats along the Great Dividing Range. It is most commonly found in areas where the mean annual rainfall exceeds 600mm (Mansergh 1984).

Nationally, the Spotted-tailed Quoll is listed as "vulnerable" under the Federal *Endangered Species Protection Act* 1992. In Victoria the status of the species has recently been revised, and it is now regarded as "endangered" (Victoria Dept. of Natural Resources and Environment 1999). The species is also listed under the Victorian *Flora and Fauna Guarantee Act* 1988. In New South Wales, the species is listed as "vulnerable" under Schedule 12 of the *National Parks and Wildlife Act* 1974.

The Spotted-tailed Quoll has suffered a decline, both in terms of individuals within populations, as well as in overall distribution. The loss and fragmentation of habitat is one of the major reasons for this decline; Mansergh (1984) estimated that over 50% of suitable quoll habitat in Victoria has been lost since European settlement. On mainland Australia, the total reduction in the range of the Spotted-tailed Quoll could also be up to 50% (Maxwell et al. 1996). Several authors (Wood-Jones 1923, Fleay 1932, Troughton 1962, Wakefield 1967, Caughley 1980) have discussed the possibility that during the first quarter of the 20th century an epidemic disease devastated populations of the larger marsupial carnivores, however the evidence for this is circumstantial. Competition with introduced predators, such as Red Foxes, *Vulpes vulpes*, and the Cat, *Felis catus*, may also have contributed to the decline of the species (Fleay 1932, Mansergh 1984, Mansergh and Belcher 1992, Watt 1993). Predation of young quolls by these predators has also been suggested (Maxwell et al. 1996). Persecution of quolls occurred as soon as European settlement took place (Fleay 1948, Rolls 1969), because quolls killed poultry. Quolls were shot, trapped and poisoned whenever they were seen as a threat. With legal protection and greater community sensitivity towards native wildlife, the risk to quolls posed by intentional persecution has declined. However quolls may still be at risk from baiting programs that fail to take the risk posed to non-target species sufficiently into account. Aspects of baiting which could put quolls at risk include the amount of 1080 placed in each bait, the type of bait used, the method by which baits are deployed and the intensity of baiting (ie number of baits deployed over a given area).

Spotted-tailed Quolls are adept at hunting and killing prey (Fleay 1948, Settle 1978). Troughton (1962) records an incident in which a Spotted-tailed Quoll was observed carefully stalking a White-faced Heron (*Ardea novaehollandiae*) feeding on the mudflats on the banks of the Hawkesbury River. He states that "In a truly cat-like manner, it ran forward when the bird's head was down, and stopped when it was raised." The small number of studies which have examined the remains of prey in quoll scats have concluded that a wide variety of animals are preyed upon, with mammalian prey predominating (Settle 1978, Alexander 1980, Boschma 1991, Belcher 1995).

Although Spotted-tailed Quolls are active hunters, like many carnivorous species they will also scavenge for food (Fleay 1948, Sharland 1963, Mansergh 1995). The suggestion that quolls could be attracted to the large meat baits that are used to poison wild dogs has been made by a number of authors (Rolls 1969, Breckwoldt 1984).

Aerial baiting is used regularly for wild dog control in the forested areas encompassed by the Cooma, Bombala and the Braidwood Rural Lands Protection Boards in southeast New South Wales. The method has long been considered as an important component of wild dog control in the areas encompassed by these Boards. Many other Rural Lands Protection Boards, in both the northeast of New South Wales (on areas inhabited by Spotted-tailed Quolls), as well as in more arid areas in the west of the State (which lack suitable forest to support populations of Spotted-tailed Quolls), also carry out aerial baiting programs.

There has been little research into the effects of aerial baiting on non-target species (McIlroy 1992). As McIlroy (1992) points out, one of the critical reasons that few field studies have investigated the impact of 1080-poisoning campaigns on animal populations is the difficulty in obtaining enough data due to the low population density of many native species. The few field studies which have been published suggest that poisoning campaigns carried out to control dingoes with unburied baits in mountain forest areas of southeastern Australia had no significant effect on populations of reasonably common small mammals and birds (McIlroy 1982, McIlroy et al. 1986, McIlroy 1992).

The study detailed below is the first attempt to determine what percentage of a Spotted-tailed Quoll population is capable of locating and consuming aerially-deployed meat baits. This is the first step in the attempt to determine the risk that this baiting method poses to the Spotted-tailed Quoll, which is the most significant non-target species potentially at risk from aerial baiting in southeastern Australia.

This project arose from the concerns of field ecologists who make up the Southeast Forests Spotted-tailed Quoll Working Group, a cross-border, cross-agency group who are attempting to achieve consistent management of the Spotted-tailed Quoll in southeast Australia. The Victorian Department of Natural Resources and Environment (DNRE) is represented on this working group, and although aerial baiting is not a baiting technique practiced in Victoria, DNRE supported the project in the interest of an increased understanding of quoll ecology and management.

Materials & Methods

Introduction

The LD50 (the lethal dose required to kill 50% of a population) of Spotted-tailed Quolls to the toxin monoflouroacetate (compound 1080) was determined to be 1.85mg/kg (McIlroy 1981, McIlroy 1986). Death is a distinct possibility for the majority of quolls that consume aerially deployed meat baits, which, in baiting programs undertaken in southeast New South Wales, are routinely injected with 6mg of 1080. While the effects of consuming poison baits on an *individual* quoll have been documented, there is no data that has quantified the risk to Spotted-tailed Quoll *populations* that inhabit an area subject to a baiting program.

This study is designed to determine the percentage of a sampled population of Spotted-tailed Quolls that locate and consume aerially deployed baits, using a non-lethal approach. The method employs the use of a non-toxic biomarker, which is injected into the meat baits rather than the toxin 1080. By determining the percentage of the population that is able to locate and consume these baits, a preliminary assessment of the risk that this type of baiting poses to quolls can be made.

It is likely that the most conclusive method to determine the "actual" short-term impact on a population of Spotted-tailed Quolls is to capture and radio-collar as many individuals as possible, release them, carry out an aerial baiting program using 1080-injected baits, and subsequently radio-track the quolls to determine the survival rate. This type of approach is unacceptable in southeastern Australia for two reasons. Firstly, the species is a nationally listed threatened taxon, which appears to be less common in the southern part of its mainland range, compared to northeast New South Wales. Secondly, based on the dietary ecology of the species, there is a strong suspicion that a high percentage of the quoll population would consume the baits. There are also logistic and economic reasons that preclude such an approach. Locating animals that are radio collared can be difficult, especially if they have died deep within a rock den, and a satisfactory signal cannot be received. Undertaking such a radio-tracking program can be costly, given the number of animals which would require collaring, the large home range of these animals, and the significant period of time that radio-tracking would have to take place post-baiting to ensure that definitive results are generated.

Study Site

The project was carried out in the southern part of Tallaganda State Forest (State Forest No 577), and the northern section of the Badja State Forest (State Forest No 567), in southeastern New South Wales. The southern end of the study site (AMG 8826 301 133) is approximately 45km northeast of Cooma, and the northern end of the study site (AMG 8826 295 392) is approximately 60km southeast of Canberra.

The Tallaganda State Forest lies on the Gourock Range, and is a strip of forest, approximately 60km long, in a north-south direction, and no more than 10km wide (and often much narrower) from east to west. It is bounded by cleared land to the west, north and east. To the south, Tallaganda State Forest it is connected to Badja State Forest and the large, forested and relatively inaccessible Deua National Park (80,000ha) and Wadbilliga National Park (76,400ha). The national parks are not aerially baited.

The Braidwood Rural Lands Protection Board has carried out aerial baiting programs on an annual basis in Tallaganda State Forest for at least the last 16 years (Phil McGrath pers.comm.).

Tallaganda and Badja State Forests are managed for the commercial harvesting of native hardwood timbers by State Forests of New South Wales. The vegetation on the study site is tableland forest, growing at elevations between 900 to 1300 m above sea level. White Ash, *Eucalyptus fraxinoides*, Shining Gum, *E. nitens* and Brown Barrel, *E. fastigata*, are the more common tree species occurring in the area. The understorey tends to be shrubby, but can be relatively open. The riparian gullies tend to have an overstorey of Manna Gums, *E. viminalis*, with an understorey of treeferns and ferns.

The area receives an annual rainfall of between 800-900mm. Winters are cool to cold, with regular winter rain and occasional snow falls. Summers are mild to hot, and fogs and rainfall occur regularly during this season as a result of the uplift of moist coastal air (Anon 1995).

It was known that a population of Spotted-tailed Quolls was extant in Tallaganda State Forest, as a result of previous studies in the area (Belcher 1998).

Bait Preparation

The Vertebrate Pest Research Department of the Victorian Institute of Animal Science (VIAS), which is part of DNRE, supplied Rhodamine B in powder form. This powder was mixed with water to create a solution of Rhodamine B. A concentration of 10mg per kilogram of animal weight was used, which was regarded as a dosage rate sufficient to mark vibrissae (David Fairbridge pers. comm.). In order to mark Spotted-tailed Quolls that would weigh up to 5kg (a weight which they rarely reach), 50mg of Rhodamine B was dissolved into 1 ml of water to provide the correct dose per bait. This solution was then injected into fresh kangaroo meat, each piece weighing 200-250g. The meat baits generally absorbed the majority of the 1 ml solution, with very little leakage.

Following injection, the meat baits were allowed to air-dry for two days. They were then placed into plastic buckets, and loaded onto a helicopter for deployment.

¹Phil McGrath, Braidwood Rural Lands Protection Board

²David Fairbridge, Vertebrate Pest Research Department, Victorian Institute of Animal science, Frankstone

Bait Palatability

A calibration trial in which four Spotted-tailed Quolls were presented with dead baby chickens injected with 25 mg of Rhodamine B was carried out in 1998. All four quolls were seen to consume at least 50% of the dyed food within the first hour (Penny Fisher ³ pers. comm.), which would suggest that the dye did not affect the palatability of the food.

Baiting Methodology

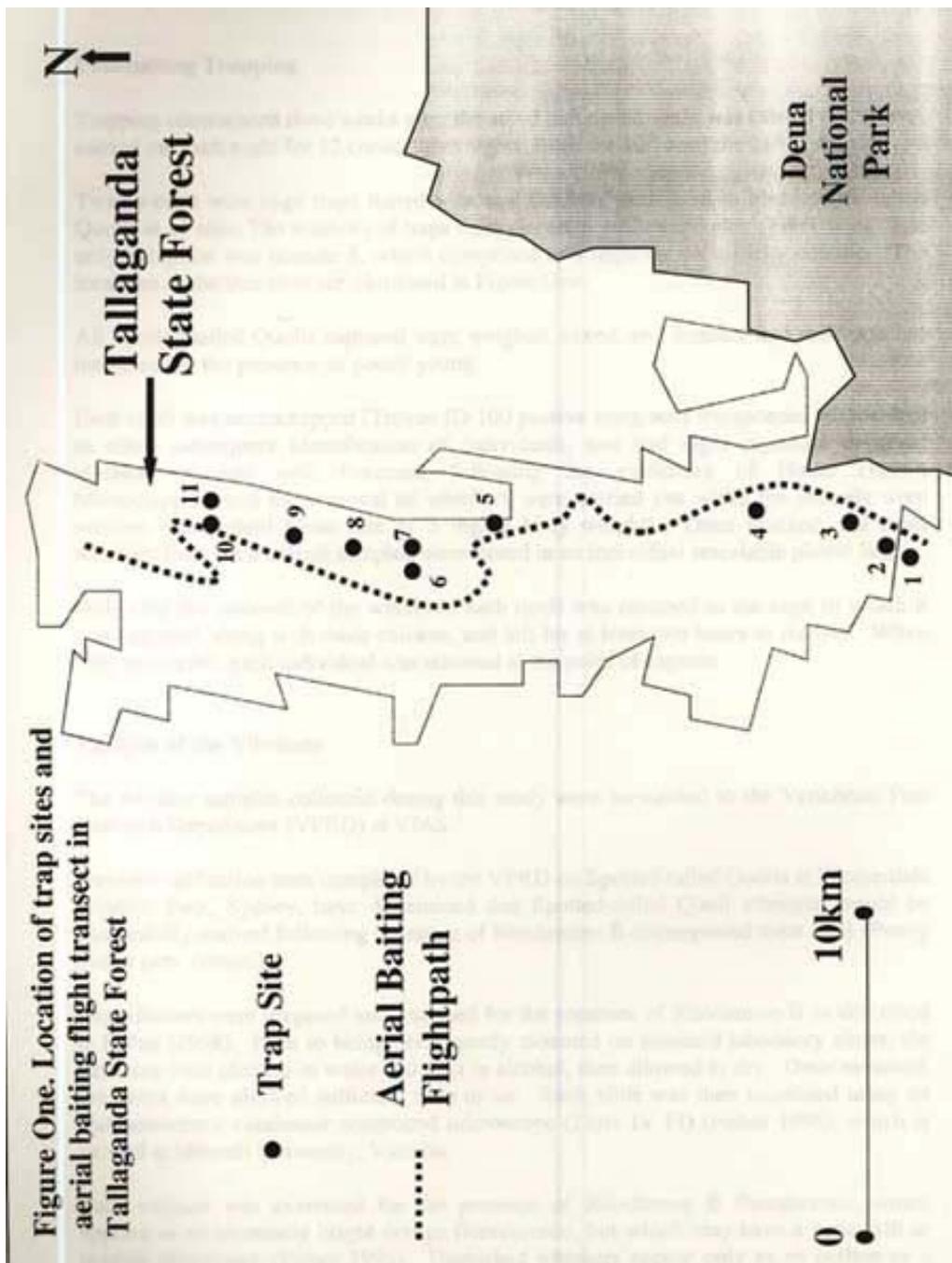
The baiting methodology used during this study replicated that used by the Rural Lands Protection Boards (RLPB) in southeastern New South Wales. Baiting methodology between agencies varies somewhat, with the New South Wales National Parks & Wildlife Service baiting at a much-reduced intensity (10 baits per kilometre) and often using horsemeat or beef (John McIlroy ⁴ pers. comm.). For the purposes of this project, it was considered appropriate to adopt the methodology preferred by the Braidwood RLPB to bait the study site.

The baiting methodology was resolved during a meeting with representatives of the various RLPBs in southeastern New South Wales. Winston Phillips (Cooma RLPB), Phil McGrath (Braidwood RLPB), and Graeme Hillyer (Bombala RLPB) attended the meeting. Representatives of the South Coast RLPB (based at Bega) declined the invitation, on the grounds that they are not currently involved in aerial baiting programs.

A 30km transect was flown over the Tallaganda State Forest, from near Pikes Saddle in the south (AMG 8826 305138) to Round Mount in the north (AMG 8826 299479). The baiting intensity was the same as a standard RLPB baiting program, with approximately 40 baits dropped per kilometre. The type of meat bait used in the study (detailed above) was also the same as that used in RLPB aerial baiting programs, and the program was carried out during winter (July), which is the season when the majority of baiting programs are undertaken.

Baiting took place on the 20th of July 1999. A total of 1200 meat baits were dropped on the transect flown over Tallaganda State Forest (Figure One).

Penny Fisher. Vertebrate Pest Research Department, Victorian Institute of Animal Science, Frankston °
John McIlroy, Wildlife Consultant, 32 Hempleman Drive, Akaroa, New Zealand



Post-baiting Trapping

Trapping commenced three weeks after the aerial baiting program was carried out. It was carried out each night for 12 consecutive nights, from the 10th until the 21st of August.

Twenty-eight wire cage traps baited with raw chicken were used to trap Spotted-tailed Quolls at 11 sites. The majority of traps were placed in gullies and along creek lines. The only exception was trap site 8, which comprised two traps set on a rocky outcrop. The locations of the trap sites are illustrated in Figure One.

All Spotted-tailed Quolls captured were weighed, sexed, and females had their pouches inspected for the presence of pouch young.

Each quoll was microchipped (Trovan ID-100 passive integrated transponder microchips) to allow subsequent identification of individuals, and had eight mystacial or genal vibrissae plucked with tweezers, following the guidelines of Fisher (1998). Microchipping and the removal of whiskers were carried out while the animals were sedated with Zoletil (dose rate of 5 mg/kg body weight). Once plucked, the eight whiskers from each animal sampled were stored in an individual resealable plastic bag.

Following the removal of the whiskers, each quoll was returned to *the cage* in which it was captured, along with more chicken, and left for at least two hours to recover. When fully recovered, each individual was released at the point of capture.

Analysis of the Vibrissae

The whisker samples collected during this study were forwarded to the Vertebrate Pest Research Department (VPRD) at VIAS.

Previous calibration tests completed by the VPRD on Spotted-tailed Quolls at Featherdale Wildlife Park, Sydney, have determined that Spotted-tailed Quoll vibrissae would be successfully marked following ingestion of Rhodamine B-impregnated meat baits (Penny Fisher pers. comm.).

The whiskers were prepared and analysed for the presence of Rhodamine B as described in Fisher (1998). Prior to being permanently mounted on standard laboratory slides, the whiskers were cleaned in water and then in alcohol, then allowed to dry. Once mounted, the slides were allowed sufficient time to set. Each slide was then examined using an epifluorescence condenser compound microscope (Zeiss IV FI) (Fisher 1998), which is located at Monash University, Victoria.

Each whisker was examined for the presence of Rhodamine B fluorescence, which appears as an extremely bright orange fluorescence, but which may have a yellowish or reddish appearance (Fisher 1998). Unmarked whiskers appear only as an outline or a shadow against the background, whereas the bright fluorescence of a Rhodamine B band

may be so bright that it has a "white-hot" or "halo" appearance (Fisher 1998). The consumption of a bait injected with Rhodamine B will show up as a single band; several baits consumed over a period of several days may result in whiskers in which several bands of Rhodamine B can be seen (David Fairbridge pers. comm.). If, however, several baits are consumed over a short period (ie within a day), it is possible that only a single Rhodamine B band will be visible.

Results

Post-baiting Trapping Results

Sixteen Spotted-tailed Quolls were captured on 41 occasions during the 12 nights of trapping. Seven female quolls were captured, four of which had pouch young. Nine male quolls were captured. The details of each quoll are listed in Table One.

Results of the Vibrissae Analysis

The analysis of the vibrissae revealed that ten of the 16 Spotted-tailed Quolls captured had been marked with Rhodamine B, indicating that ten quolls had fed upon at least one of the baits which had been injected with Rhodamine B. Six of the nine males were marked, and four of the seven females were marked. Three of the four females that had pouched young had consumed Rhodamine B-injected baits.

The individuals which were identified as having fed upon a Rhodamine B bait are highlighted in bold in Table One. Those quolls that appear to have had fed on more than one bait are indicated with an asterix.

Table One: Details concerning Spotted-tailed Quolls captured during this study
Quolls which were identified as having fed upon Rhodamine B injected baits are indicated in bold;
quolls which were identified as having fed upon several baits are identified with an asterix ()*

PTT tag Number	Sex	Weight (kg)	Date of first Capture	Trap Site	AMG	Trap Number	No. of Pouch Young	No. of Times Recaptured
00-0134-E0B5	F	1.9	8/11/99	1	8826 304 144	1st trap	6 pouch young	4
00-0121-AC2C	F	1	8/12/99	10	8826 293 388	1st trap	nil	2
00-012E-AEE6	M	2	13/8/99	1	8826 304 144	1st trap	NA	0
00-0136-5300	F	2	13/08/99	4	8826 304 185	4th trap	6 pouch young	2
00-0141-C688	F	0.95	13/8/99	7	8826 288 325	2nd trap	nil	0
* 00-0121-67E7	F	1.6	13/8/99	10	8826 292 388	2nd trap	nil	5
00-0134-E3A3	M	3.3	13/8/99	10	8826 292 388	1st trap	NA	4
00-0134-E237	M	3	14/8/99	6	8826 286 326	2nd trap	NA	2
00-0122-64E4	F	1.5	16/8/99	8	8826 284 353	trap near latrine	5 pouch young	1
* 00-0122-5F0A	F	1.1	18/8/99	8	8826 284 353	trap near latrine	4 pouch young	2
00-0136-3F8F	M	3	19/8/99	8	8826 284 353	trap away from latrine	NA	1
00-0134-9D9F	M	2.9	20/8/99	3	8826 305 149	trap upstream	NA	0
00-0127-E093	M	2	20/8/99	6	8826 286 325	1st trap	NA	0
00-0134-98B6	M	2.5	20/8/99	10	8826 292 388	2nd trap	NA	2
* 00-0134-9C19	M	2.7	21/8/99	8	8826 284 353	trap near latrine	NA	0
00-0121-F8B3	M	1.4	22/8/99	7	8826 288 325	2nd trap	NA	0

Discussion

The government agencies responsible for the management of the forested land in eastern Australia are committed to maintaining and improving the biodiversity found within the forest. The Spotted-tailed Quoll is an important component of the fauna of the forests in eastern Australia. It is important as a top-order carnivore, and as the last quoll species extant in southeastern Australia. It is also important as the largest extant quoll species, and as the last of an ancient lineage of forest-dependent quoll species. The Spotted-tailed Quoll is not common anywhere in southeast Australia; populations of the species occur at low densities and the distribution of the species is fragmented. It is important that the processes that have been identified as being detrimental to this threatened species are prevented, especially if they are human-induced.

The results of this study provide the first evidence that Spotted-tailed Quolls are capable of locating and consuming meat baits deployed from aircraft as part of a wild dog control program.

An analysis of the vibrissae found that 62.5% of the quoll population sampled had fed upon Rhodamine B-injected baits. The conclusion to be drawn from this result is that aerial baiting at the intensity used during this study is an activity that has, in the short term at least, the potential to have a serious deleterious impact on populations of Spotted-tailed Quolls.

Possibly more significant is that 75% of the adult breeding female quolls (ie those carrying pouch young) captured were found to have eaten a Rhodamine B bait. Each of these females weighed 2 kg or less. The LD 50 for this species is 1.85 mg/kg (McIlroy 1981). Given that aerially deployed baits are injected with 6 mg of 1080, it is highly likely that the majority of these females would have died if a poison baiting program had been carried out. Such an effect on the actively reproductive female component of the population could have a serious effect on the viability of that population.

Examination of the sampled vibrissae revealed that three quolls had consumed several baits. Specifically, the banding patterns indicated that one animal had fed upon two baits, a second animal on three baits, and a third animal on between three and five baits (David Fairbridge pers. comm.) There is a possibility that the seven other quolls which were marked had also consumed multiple baits, however if the baits were consumed in a short period of time the marking in the vibrissae may appear as a single band (David Fairbridge pers. comm.). Consumption of a number of poison baits over a short period of time greatly increases the likelihood that death would occur. It is possible that a reduced baiting intensity (similar to the 10 baits per kilometre intensity used by New South Wales National Parks & Wildlife Service) may result in fewer individuals consuming multiple baits, and possibly a smaller percentage of the quoll population locating and consuming baits. Further research in which a simulated baiting program using Rhodamine B baits at a reduced baiting intensity (10 baits per kilometre) may provide a valuable comparison to the results obtained during this study.

The high number of Spotted-tailed Quolls that had located and consumed Rhodamine B-injected baits is not surprising given the dietary ecology of the species in combination with the baiting methodology employed. Green and Scarborough (1990) believe that the Spotted-tailed Quoll "appears to be greatly dependent upon its olfactory system, as it is almost constantly sniffing the ground and its surroundings as if attempting to interpret the faintest odours and scent trails." Like most carnivorous mammals that consume carrion, Spotted-tailed Quolls would regard meat baits dropped from an aircraft as suitable food. Spotted-tailed Quolls are active and persistent in their foraging, and can cover considerable distances overnight. Captive Spotted-tailed Quolls have been observed consuming 200g of meat within ten minutes (A. Murray pers obs., Featherdale Wildlife Park). Given the carnivorous and voracious nature of the Spotted-tailed Quoll, and the palatable nature of the baits being deployed, it is likely that on most occasions any meat bait encountered would be entirely consumed. The consumption of baits injected with 6 mg of 1080 would probably result in death for the majority of Spotted-tailed Quolls.

Aerial baiting within Tallaganda State Forest has been undertaken on an annual basis from at least 1982 until 1996 (Phil McGrath pers. comm.). In 1997 and 1998 the aerial baiting effort was confined to the freehold land border on the eastern side of the State Forest. Given the results of this study, it may appear contradictory that such a relatively large and trappable Spotted-tailed Quoll population exists in an area that has been systematically aerially baited for at least the last 15 years. The reasons for this can only be surmised. It is likely that each year a significant proportion of the quoll population has been poisoned, as the results of this study suggest. However some quolls may not encounter baits at all, and some quolls may receive a sub-lethal dose and recover. It is unlikely, however, that the resident quoll population would remain viable in the face of a poisoning program which reduced the population by 60% each winter. Deua and Wadbilliga National Parks, which collectively comprise over 150,000 ha of conservation reserve, border Tallaganda State Forest. The parks are not aerially baited. Given the high level of connectivity of the forest, it is possible that each year young quolls disperse into Tallaganda State Forest from the adjoining national parks during late spring and early summer. The dispersal behaviour of young Spotted-tailed Quolls post-weaning is not well known, however it is likely that suitable vacant habitat (brought about by the aerial baiting program) would be reoccupied by young quolls looking to establish their own territory.

How serious an impact aerial baiting has on a population of Spotted-tailed Quolls in the longer term probably depends on a number of factors. The initial size of the quoll population will be important, as it could be assumed that a larger population will recover at a greater rate from a baiting event than a smaller one. The size of the inhabited area that is aerially baited will also be important. If a significant area of unbaited forest which supports quolls lies adjacent to the area which is baited, it could be assumed that the baited area is more likely to be reoccupied by dispersing juvenile quolls, when compared to an isolated area of forest which is baited in its entirety. The period of time between baiting sessions will influence the potential for a quoll population to recover. In many areas, an annual baiting program may be enough to lead to localised extinctions of quolls, and prevent the reoccupation of suitable habitat. Finally, the impact of an aerial baiting program may exacerbate the other threatening processes operating upon a quoll population, thereby preventing or retarding the recovery of the species, or worse, causing

it to decline at a faster rate. Other processes that might be operating which are detrimental to quoll populations include habitat fragmentation, inappropriate or high intensity fire regimes and competition with introduced predators.

The impact on a resident quoll population from an aerial baiting program is likely to be more severe when the population is small, isolated or is in forest which is sub-optimal habitat. The impact will be more severe when the area incorporated in the aerial baiting program is larger, and when the period of time between baiting is reduced. Concentrating baiting transects in those areas where quolls most frequent (eg gullies, creek lines, saddles and drainage lines) will also increase the likelihood of quolls finding baits.

Canid control will continue as an important activity for both the protection of domestic stock and as a method of wildlife conservation. Programs that use poison baits to target the introduced Red Fox are seen as an important component of maintaining and improving biological diversity. This introduced predator preys on a wide variety of native wildlife, and mammal species that weigh between 35 g and 5.5 kg are at particular risk (Burbidge and McKenzie 1989). While baiting programs are the most effective and efficient method of controlling both foxes and wild dogs that inhabit forested country, techniques must be adopted which minimise the risk to non-target species such as the Spotted-tailed Quoll. It has been demonstrated (Murray 1998) that Spotted-tailed Quolls in captivity are not particularly inclined to excavate meat baits which are buried within constructed bait stations at a depth of 10cm or more. Research underway in East Gippsland, Victoria, is demonstrating that foxes and wild dogs living in forested habitats are still able to locate and excavate baits buried at these depths (Murray 1999). An important result of this research to date is that large areas of forest (on excess of 10,000 ha) can be kept relatively free of foxes using the buried bait method (A. Murray pers. obs.), a technique which is believed to minimise the risk to Spotted-tailed Quolls. In order to confirm this belief, a field trial using baits injected with Rhodamine B and buried under 10cm of soil in suitably constructed bait stations should be undertaken over a period of six weeks or more. Similar to this trial, quolls would be trapped several weeks following the end of the baiting program, have eight whiskers removed and analysed. In addition to cage-trapping quolls, dogs and foxes could also be trapped and whiskers analysed, to demonstrate that these target species were removing and consuming the baits.

Conclusions

The conclusion that can be most clearly drawn from this study is that aerial baiting has the potential to have a severe detrimental impact on a resident population of Spotted-tailed Quolls. It has clearly been demonstrated that using the baiting methodology employed by the Rural Lands Protection Boards, quolls are able to find and consume the baits. It is also clear that the majority of the sampled quoll population in the study area (62.5%) consumed these baits during a single baiting event. Both sexes consumed baits, and most disturbing was the high rate (75%) of actively reproductive females that had consumed baits.

Recommendations

- Aerial baiting at the baiting intensity employed during this trial should be considered an inappropriate baiting technique for forested habitats that are, or may be, inhabited by populations of Spotted-tailed Quoll. Where possible, it should be phased out as a method of bait deployment.
- Government agencies that manage forested land should consider implementing canid control techniques on the land they manage which reduce the risk of poisoning Spotted-tailed Quolls, and which target canid species more specifically. Burying baits in bait stations is one method by which this can be achieved.
- The public should be made aware that aerial baiting could be having a detrimental impact on Spotted-tailed Quolls. It is important that the public receives the correct message about canid control in general and aerial baiting in particular. It must be stressed to the public that: (a) canid control is an integral part of the conservation program; (b) aerial baiting is an appropriate technique for controlling dogs and foxes in large areas of remote and inaccessible parts of Australia, which are not inhabited by Spotted-tailed Quolls. Much of Victoria, New South Wales and Queensland do not support suitable habitat for Spotted-tailed Quolls, and potentially could be aeri ally baited to significantly reduce fox numbers.
- A trial using Rhodamine B-injected baits buried under 10cm of soil in constructed bait stations should be carried out in an area known to support a Spotted-tailed Quoll population, in order to ascertain if free-ranging quolls are willing to excavate buried baits. Previous research with captive quolls has suggested that this species is not particularly inclined to excavate buried baits (Murray 1998). This trial would determine if this were the case in the field.
- A comparative simulated aerial baiting program using a lower intensity of Rhodamine B injected baits could also be undertaken. A baiting intensity of 10 baits per kilometre is suggested. The purpose of this trial would be to determine if a reduced level of baiting intensity resulted in a lower proportion of the quoll population locating baits.

Acknowledgments

Virgin Helicopters stepped in at very short notice to provide a Squirrel helicopter for the simulated aerial baiting run. David Fairbridge (Vertebrate Pest Research Department, Victorian Institute of Animal Science) provided the Rhodamine B in a powder form to be injected into the meat baits. Frank Bursana (VIAS) provided additional information concerning the application of the Rhodamine B. The Natural Australian Meat Company (Laverton North, Victoria) prepared the 1200 kangaroo meat baits. Craig Mills assisted Rob Poore in dispatching the baits from the helicopter. David Fairbridge carried out analysis of the whiskers. Cath Renwick ensured that the media were made aware of the project, and arranged several radio interviews.

John McIlroy, Stephen Henry and David Fairbridge, all of whom reviewed drafts of this report, and made useful contributions to the manuscript.

This research was carried out under the authority of National Parks & Wildlife Service Scientific Licence Number A1571, and with the authority granted under the State Forests Special Purposes Permit No 05378.

References

- Alexander, D. (1980) Diet of the Tiger Quoll (*Dasyurus maculatus* Kerr) in an area of New England National Park northeastern New South Wales. Natural Resources Project, University of New England, Armidale. (unpubl.)
- Anon. (1995) Proposed forestry operations in the Queanbeyan and Badja Management Area. Environmental Impacts Statement. Southern Region, State Forests of NSW.
- Belcher, C. A. (1995) Diet of the Tiger Quoll (*Dasyurus maculatus*) in East Gippsland, Victoria.
Australian Wildlife Research 22: 341-357.
- Belcher, C.A. (1998) Ecology of the Tiger Quoll in south-east New South Wales. Report to Environment Australia, National Forests Program (unpubl.)
- Boschma, D. 1. (1991) A dietary analysis of *Dasyurus maculatus* (Ken-) in the area below Dangar's Falls, Armidale.
Natural Resources Project, University of New England, Armidale. (unpubL)
- Breckwolfdt, R. (1984) *Wildlife in the home paddock*.
Angus & Robertson, Australia.
- Burbidge, A.A. and McKenzie, N.L. (1989) Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation* 50: 143 - 198
- Caughley, J. (1980) Native Quolls and Tiger Quolls.
Pges 44-48 in: Haigh, C. (ed.) *Endangered animals of New South Wales*. NSW National Parks and Wildlife Service, Sydney.
- Fisher, P. (1998) Rhodamine B as a marker for the assessment of non-toxic bait uptake by animals.
Report Series No 4, Vertebrate Pest Research Department, Victorian Institute of Animal Science, Department of Natural Resources and Environment, Victoria. 70pp.
- Fleay, D. (1932) The rare dasyures (native cats).
Victorian Naturalist 49: 63-69.
- Fleay, D. (1948) Australia's marsupial Tiger Cat: a creature of increasing rarity and extreme pugnacity.
Wildlife 10: 459-464.
- Green, R. II. and Scarborough, T. J. (1990) The Spotted-tailed quoll, *Dasyurus maculatus* (Dasyuridae, Marsupialia) in Tasmania. *Tasmanian Naturalist* 100: 1-15

- Mansergh, I. (1984) *The status, distribution and abundance of Dasyurus maculatus (Tiger quoll) in Australia, with particular reference to Victoria. The Australian Zoologist 21(2): 109-122.*
- Mansergh, I. M. (1995) *Spot-tailed Quoll*
in: Menkhorst, P. W. (ed) *Mammals of Victoria.*
Oxford University Press, Melbourne, pp51-52.
- Mansergh, I. and Belcher, C. (1992). *Tiger Quoll Action Statement.*
Action Statement No. 15, Dept. of Conservation and Environment, Victoria.
- Maxwell, S., Burbidge, A.A. and Morris, K. (eds.) (1996) *The 1996 Action Plan for Australian Marsupials and Monotremes.*
Australasian marsupial and Monotreme Specialist Group, IUCN Species Survival Commission
- McIlroy, J. C. (1981) *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 mammals to 1080 poison.*
Pges 267-271 in: Archer, M. (ed.) *Carnivorous Marsupials. Royal Zoological Society of NSW, Sydney.*
- McIlroy, J. C. (1986) *The sensitivity of Australian animals to 1080 poison. IX. Comparisons between the major groups of animals, and the potential danger non-target species face from 1080 poisoning campaigns.*
Australian Wildlife Research 13: 39-48.
- McIlroy, J.C., Gifford, E.J. and Cooper, R.J. (1986) *Effects on non-target animal populations of wild dog trail-baiting campaigns with 1080 poison.*
Australian Wildlife Research 13:447-453
- McIlroy, J. C. (1992) *The effect on Australian animals of 1080 poisoning campaigns. pp 356-359 in: Borrecco, J.E. and Marsh, R.E. (eds.) Proceedings of the 15th Vertebrate Pest Conference. University of California, Davis.*
- Murray, A.J. (1998) *Tigers and 1080: the threat posed by buried poison baits to Spotted-tailed Quolls in the Australian Alps national parks. Report to the Australian Alps Liaison Committee. 84pp (unpubL)*

"

- Murray, A.J. (1999) *"Project Deliverance : the impact of fox predation on the conservation of critical-weight-range mammals in the forests of southeastern Australia.*
Final Report of Project FN-34 to Environment Australia. (unpubl.) 100pp.
- Rolls, E. (1969) *They All Ran Wild.* Angus and Robertson, Sydney.
- Settle, G.A. (1978) The quiddity of Tiger Quolls.
Australian Natural History 19 (5): 165-169
- Sharland, M. (1963) *Tasmanian Wild Life.* Melbourne University Press, Victoria. 83pp.
- Troughton, E. (1962) *Furred animals of Australia.* Angus and Robertson, Australia. 376 pp.
- Victoria Dept. of Natural Resources and Environment (1999) *Threatened vertebrate fauna in Victoria 1999: a systematic list of vertebrate fauna considered extinct, at risk of extinction or in major decline in Victoria.*
DNRE, Victoria. 10pp.
- Wakefield, N.A. (1967) Quoll, the "native cat".
Pges 44-47 in *Naturalist's Diary.* Longmans, Australia. 214 pp.
- Watt, A. (1993) Conservation status and draft management plan for *Dasyurus maculatus* and *D. hallucatus* in Southern Queensland.
Final report to the Qld. Dept. of Environment and Heritage and the Dpt. of the Environment, Sport and Territories.
- Wood-Jones, F. W. (1923). *The mammals of South Australia.* Government Printer, Adelaide.