FERAL PESTS PROGRAM

PROJECT 11

METHODS OF BROADSCALE CONTROL OF FERAL CATS, AND FOX CONTROL AT A NUMBAT RE-INTRODUCTION SITE. YEAR 2

Final Report, March 1995

by

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SUMMARY

Pen trials to determine the relative preferences of captive semi-feral cats for five manufactured fox and cat bait materials and the effectiveness of two taste-enhancing additives have been completed. The results indicate that the bait known as "pussoff" and dried kangaroo meat baits were the most preferred bait types in the trial. However, the effect of the additive "digest" was dramatic, and increased the acceptability of "pussoff" and kangaroo meat significantly. Again, there was no difference in acceptability between these two bait types plus additives.

Field trials were then run in which a three-way choice was presented, between the two preferred bait types with "pussoff" and "foxoff" bait with no additive. Trials were run at a semi-arid coastal site, an arid inland site and a semi-arid inland site. Cat numbers at the first two sites were very low, but high numbers were found at the third site. Results from all sites again showed that the effect of "digest" was greater than any difference in preference for the bait type. Serum samples were collected from fifty cats.

Comparison of effectiveness in the field between the newly developed cat bait and standard fox baits was carried out using unpoisoned baits containing different biomarkers, rather than by measuring mortality of radio-collared cats as originally proposed. This required a trial of several biomarkers to establish which were effective in cats, and which could be used in the same field trial to compare the uptake of different baits. Captive cats were fed the two bait types containing either rhodamine B, fluoroscein or tetracycline-HCl. Results from this biomarker trial indicated that rhodamine B and tetracycline-HCl could be used in combination, as oral markers, for the examination of bait uptake.

The baiting effectiveness trial was carried out at Kanandah Station on the Nullarbor Plain, in October/November 1994. By using a different biomarker in each bait type, then sampling the cat population in the trial area by shooting, the proportion of the feral cat population that ate unpoisoned baits of each type was measured. The baits used were standard dried roo meat baits used for fox control in Western Australia

labelled with rhodamine B, and the pussoff/digest bait with tetracycline. The two bait types were placed alternately along transect lines at a spacing equivalent to 10 baits per km^2. On the southern half of the study site, a visual attractant (flagging tape) was placed near the pussoff/digest bait but not near the roo meat bait.

Thirty-five cats were shot on the study site within two weeks following the bait lay. Twenty-five had eaten at least one pussoff/digest bait, and only one had eaten a roo meat bait. Nine had not taken a bait. In the area where the visual attractant was used, 78% of cats had eaten pussoff/digest baits (19 took pussoff/digest, one took roo meat, three took no bait). Using a toxic bait, the proportion of the population killed would have been even higher, given that some cats probably took multiple baits, reducing the availability of baits for others. This bait type and method of placement shows great promise.

Fox control was carried out in May and September 1994 over 40 000 ha surrounding the numbat re-introduction area at Karroun Hill Nature Reserve, by aerial baiting at 7.5 baits per km^2. This baiting regime was shown to be extremely effective, reducing fox numbers below the level detectable by the cyanide transect method, but cats are still present. The progress of radio-collared numbats at Karroun Hill has been monitored. Predation of numbats has continued under the regime of fox control with at least half of the victims being taken by introduced mammals, probably cats. It is recommended that cat baiting be carried out in conjunction with fox control in the numbat reintroduction site.

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PREFACE

This project has two major components. Research into methods of broadscale control of feral cats (Scope items 1-4 and 8-9) was carried out by Dr. Algar. The process of development of the project, and aspects of cat behaviour elucidated through these studies, required changes in the methodology from that originally proposed in the Scope for the project These changes were outlined in the Progress Report submitted in June 1994. The second component of the project, fox control at Numbat re-introduction site (Scope items 5-7) was carried out by Dr Friend according to the original proposal.

SECTION A: METHODS OF BROADSCALE CONTROL OF FERAL CATS

BAIT ACCEPTABILITY: PEN TRIALS (SCOPE ITEM 1)

1. Carry out bait acceptability tests on commercially available fox and cat bait types in pen trials.

These pen trials have been completed. A report, presented as an Appendix to our final report on Year 1 of the project, was forwarded to ANCA Feral Pests Program in February 1994. The results of the trials indicated a distinct ranking of preference for the various bait mediums offered. This occurred despite the fact that several of the mediums were constituted from essentially the same substances. A significant preference was shown by the cats for the size-reduced standard roo meat bait and the prototype fishmeal bait "pussoff", while there was no significant preference for the Incitec extruded roo meat bait. The least preferred baits were meat-substitute bait "foxoff" and the pelletised fishmeal bait supplied by the New Zealand Department of Conservation. These results suggest that cats display some sensitivity, not only to the taste of a bait, but also to its physical form. This has been highlighted in nutritional literature where it is suggested that cats are much more sensitive to the physical form and taste of their food than are dogs and many other mammals.

Of the two additives thought likely to most improve the taste of the bait mediums and tested in pen trials, digest was significantly more preferred than L-alanine. Consumption of the bait mediums "standard" and pussoff with the additive digest was significantly greater than the controls. It would appear, even at this early stage of research, that the use of digest is critical to the success of feral cat baiting campaigns.

The pen trials were designed to provide information on bait options that could be successful in controlling feral cat populations. Several bait types were to be selected from the range of responses achieved from the pen trials to test on feral cats in the field. We selected the two most preferred bait types, roo meat with digest and pussoff with digest, and foxoff as the least preferred, control bait. Fortuitously, this combination of bait types covers the range of bait medium substances available.

BAIT ACCEPTABILITY: FIELD TRIALS (SCOPE ITEM 2)

2. Carry out bait acceptability tests on commercially available fox and cat baits in field trials at coastal semi-arid zone, inland semi-arid zone and inland arid zone sites.

Introduction

Despite the lack of data, feral cats are widely acknowledged as a serious threat to populations of small to medium-sized vertebrates in Australia. Cats are opportunistic predators, feeding on a wide range of prey species (Coman and Brunner 1972; Jones and Coman 1981). Predation by cats was most probably the cause of the extinction of a number of species (Serventy and Marshall 1964). Predation by feral cats may therefore seriously affect the continued survival of many native species persisting at low population densities. This has been highlighted during recent re-introduction programmes of numbats (*Myrmecobius fasciatus*) at Karroun Hill NR (Friend and Thomas in press) and boodie (*Bettongia lesueur*) and golden bandicoots (*Isoodon auratus*) at the Gibson Desert NR (Christensen *et al.* in press). Despite aerial baiting of these reserves for fox control, cat predation has significantly affected the survival of the re-introduced species.

Control methods for feral cats have not been extensively researched in Australia. When cat control has been implemented it has generally relied on using standard fox baiting procedures. These routine procedures consist of aerial baiting campaigns (5 to 10 baits/km^2) using dried meat baits. The recommended baits are cut from kangaroo meat (120g wet-weight), injected with 4.5 mg of 1080, and then dried to 40% of their original weight. There are however, no data on the effect of fox-baiting on cats. There is circumstantial evidence that despite susceptibility to 1080 poison, cats are not as vulnerable as foxes to existing baiting campaigns. Thus, there is an urgent need to develop and implement effective feral cat control campaigns. This would require the examination of cat bait preferences.

It was necessary initially to design a technique that would allow discrimination of bait preferences, in a cafeteria trial, on feral cat populations. In this section we describe a technique, using cyanide capsules, that can be used to assess feral cat preferences for different bait types. Results of the bait acceptability trials are also presented.

Materials and Methods

Bait mediums.

Initial pen trials were designed to provide information on bait options that could be successful in controlling feral cat populations (see above). Three bait types were selected from the range of responses achieved from the pen trials to assess feral cat bait preferences. From the pen trials, we selected the two most preferred bait types (roo meat + digest and pussoff + digest) and foxoff as the least preferred, control bait. Fortuitously, this combination of bait types covers the range of bait medium substances available. These bait types are described below.

foxoff is a shelf stable meat substitute bait. Each bait weighs 55g and is 30 mm cubed. The baits are produced by Applied Biotechnologies Pty. Ltd. Melbourne. Pussoff is a prototype fishmeal-based cat bait similar in design to foxoff and produced by the same company. Kangaroo meat sausages were manufactured as an alternative to presenting kangaroo steaks.

Both the pussoff and foxoff bait mediums underwent change prior to use in the field. To every 30 mm cubed bait , 5 mL of water was added to the dried bait and heated on high for one minute in a microwave. Once heated the baits were kneaded thoroughly, their form then somewhat similar to a pastry dough. The baits were then flattened using a rolling pin to create a thin crust, the cyanide pill was then rolled into the pastry. The completed cyanide pill was covered in a smooth pastry shell and stored in a refrigerator to harden the shell prior to the use in the field.

Kangaroo meat steaks were minced and the minced contents used to fill plastic sausage skin. The sausages were approximately 5 cm x 2 cm.. The sausages were placed on drying racks and sun dried, firming the plastic skin. One end of the sausage was then opened to allow the insertion of the cyanide capsule. All baits were stored in a refrigerator.

Chicken "digest" (5% w/w) was surface coated, and sun-dried, on the pussoff and kangaroo meat sausages.

Cyanide capsules

The cyanide capsules described were a modification and refinement of a technique previously used by commercial fox hunters. The use of cyanide as a research tool has been sanctioned by the appropriate Western Australian government authorities. All operators were licensed and have met the stipulated safety requirements.

The capsules were composed of a mixture of 90% paraffin and 10% micro-crystalline wax (Candle Light Co., Bayswater WA) containing dry, commercial grade sodium cyanide (NaCN) powder. This combination of waxes produces a robust yet brittle capsule, with a relatively high melting point. The two waxes were melted together and heated to a temperature just below boiling. Capsules were coloured with a commercial wax dye (Candle Light Co., Bayswater, W.A.) to match the colour of the bait medium. Stainless steel rods were first dipped in a lubricating agent of soapy detergent water to prevent sticking and then dipped briefly in the heated wax. The wax capsules were then prized off the rods and allowed to solidify. Each capsule was 8 mm in diameter and 50 mm in length. Capsules were then inverted and left to dry at room temperature for 48 h.

The capsules were filled to three-quarters with approximately 1.0g of NaCN powder. To prevent cyanide, which is hygroscopic, from caking in the capsule the use of a free-flowing or desiccating agent was used. The agent Tixolex 28 (Kofran Chemical Co., Ltd., Melbourne Victoria) is a sodium silica aluminate ($Na_2O.Al_2O_3.SiO_2$). The free-flow agent is a white odourless powder and is mixed in with the cyanide at a rate of 5%. A cotton wool plug was placed into the capsule at its open end. Melted wax was used to seal the capsule. Cyanide capsules were then placed in water to wash off any spilled cyanide and to ensure that they were correctly sealed. The partially filled capsules were gently shaken to see whether the powder was free flowing, then air-dried and securely stored.

When a cat takes a bait, cyanide spills into its mouth as the capsule is broken. Death is virtually instantaneous, ensuring retrieval of poisoned cats. Bait preference is then assessed on the basis of kill numbers for the different bait options.

Bait stations

Bait stations were located at 100m intervals along firebreaks or tracks. Initially, baits were laid at dusk and retrieved at dawn however as the weather cooled, the baits were left in place and examined daily. To ensure that baits could not be removed from the bait site, each bait was tethered to a wooden block 100 mm x 20 mm, secured using a Demison Secura-tie fastener made of hardened plastic, and anchored to the ground by a metal peg.

Study sites

Feral cats in Western Australia may be considered a threat to native species in three broad geographic zones:- coastal; semi-arid and arid regions. Bait preference was examined at a number of sites to cover the above regions:- Peron (coastal); Wanjarri, Nullarbor and Gibson Desert Nature Reserve (arid) and Rowles Lagoon and Kambalda (semi-arid). The location of these sites is shown in Figure 1.

Statistical analysis

Simple descriptive statistics (Chi^2 tests) were used to analyse the data.

Results

The technique described above was successful in providing data on feral cat bait preferences. A total of 43 cats was collected during the bait preference trials. Bait preferences for the various study sites are presented in Table 1.

Table 1. Feral cat bait preference trials. Numbers of cats killed on each bait type offered at each study site.

Site	Bait Type			Transect baited
	Roo meat + digest	pussoff + digest	foxoff	(kms)
Peron	0	3	0	36.2
Wanjarri	2	2	0	65.0
Nullarbor	11	13	0	25.0
Gibson Desert	1	1	0	8.0
Rowles lagoon*	8	0	0	7.2
Kambalda	2	0	0	16.0

* Four inches of rain fell at this site during the three days of baiting.

The experimental approach changed during this study (see below) as our knowledge improved. As a result of changes to the technique and low sample sizes, no attempt has been made to examine differences between sites.

Results from the first two sites (Peron and Wanjarri) were disappointing because of the low cat abundance at both sites. Preliminary track surveys at both sites suggested feral cats were present but in low numbers and this was confirmed during the bait preference trials. Presence of tracks usually resulted in kills but track numbers were very low.

Initial success on the Nullarbor was limited until two crucial factors became apparent. Bait stations were initially placed at 100m intervals along tracks however, it soon become evident that cats were not utilising the tracks and therefore not finding the bait choices. A cat's sense of smell is poor in comparison to canids and their primary hunting skills rely on sight and sound. Thus, to attract cats to the bait stations we used a variety of visual attractants that flapped or moved in the wind. `Curiosity killed the cat' - cats were attracted to the bait stations and baits were taken. Bait uptake was further enhanced by leaving baits in place during the day, rather than retrieving them at dawn. The cats did not display nocturnal behaviour but rather `cat-napped' and were active throughout the day. As a result, in all subsequent study sites, visual attractants were used and baits were left in place.

Pooling the data across sites indicated a significant difference in cat preference for the three bait types ($Chi^2 = 22.4$, 2 df., $P<0.001$). Roo meat + digest and pussoff + digest were the most preferred bait types and foxoff the least preferred. Comparison of the preference for roo meat + digest and pussoff + digest indicated no significant difference between the two baits ($Chi^2 = 0.6$, 1 df., $P>0.25$).

Discussion

The technique described above has provided an effective means of examining bait preference. It is possible to examine a variety of bait forms and types. This information is critical to designing a bait for feral cat control as nutritional literature suggests that the cat is very sensitive to the physical form and taste of its food, more so than the dog and many other mammals.

Results of the field bait preference trials were similar to those obtained in the pen studies. Roo meat + digest and pussoff + digest were the most preferred baits and foxoff the least preferred. It would appear that bait uptake is significantly influenced by the use of the flavour enhancer "digest", rather than the bait medium itself. Slightly more animals consumed the roo meat baits than pussoff; however these differences

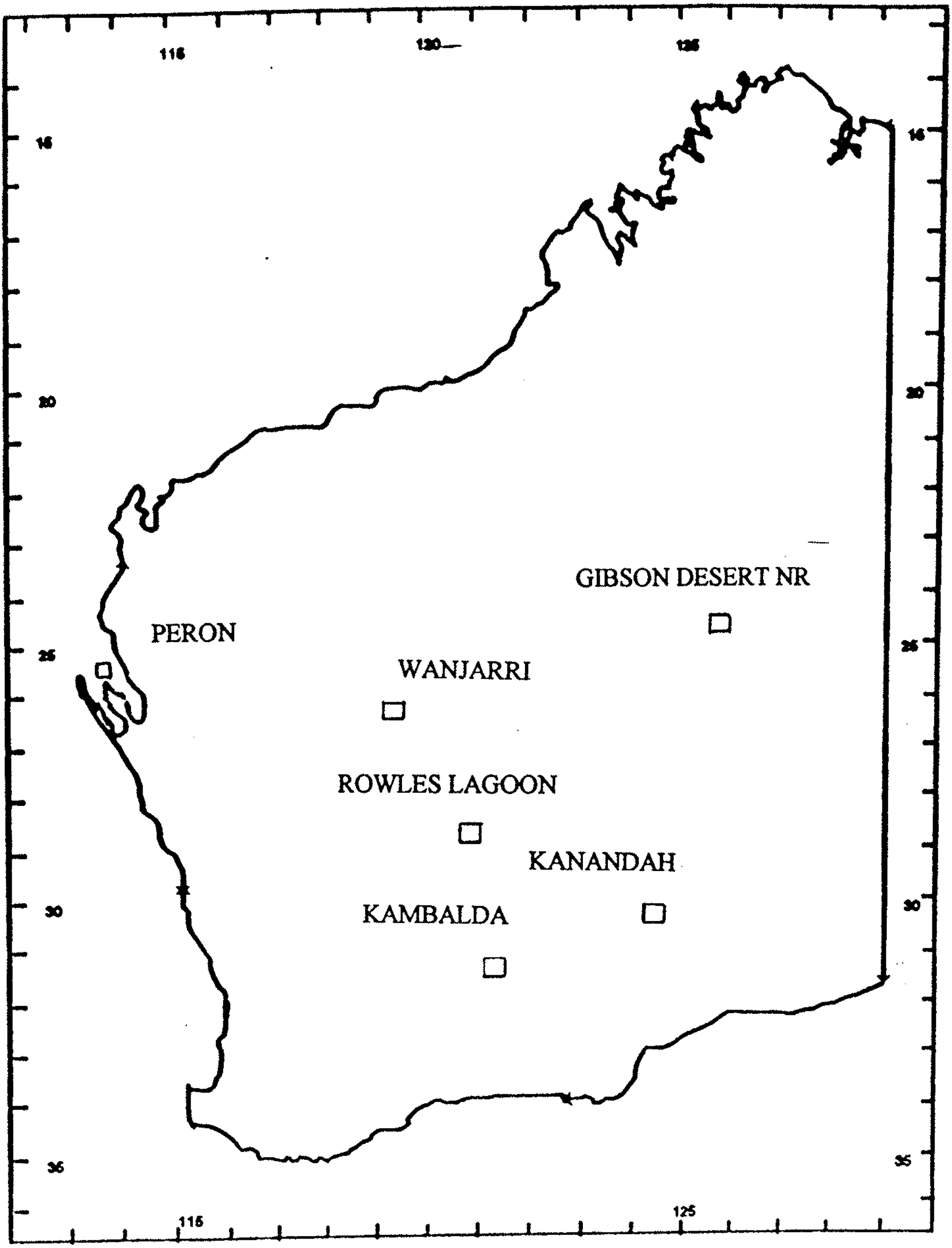


FIG 1: SELECTED SITES

were not significant. Selection of a medium for toxic bait delivery in the field may be more influenced by a variety of additional factors listed below:-

1. Observations indicate that foxes prefer roo meat to pussoff and thus, if an integrated predator control strategy is required, roo meat may well be a better choice.
2. In wet conditions, pussoff loses its binding capacity whereas, roo meat maintains its structure (see results from Rowles Lagoon).
3. Roo meat baits require freezer storage while, pussoff is shelf stable and easily transported.
4. Research is needed to examine methods to reduce ant attack on baits. The viability of both baits is significantly reduced by ant invasion and thus bait availability in the field is decreased. Results of this research may also influence the medium of choice.

Results from the bait preference trials would also suggest that there is considerable potential for the use of visual attractants in feral cat control techniques. Research into visual items that attract cats to bait stations and thus enhance bait uptake and bait efficiency has commenced.

The bait preference technique was dependent on the use of cyanide capsules. The success of the technique suggests that cyanide bait stations, with suitable attractants, will provide a simple and effective technique to sample cat populations and has the potential to generate an index of cat density (as described in the grant application for 1995).

The cyanide baiting methodology enables retrieval of cats at individual bait stations. The technique also enables the measurement of a number of biological parameters relevant to both conventional 1080 and biological control strategies. Cats retrieved on cyanide transects can provide data on social structure, reproductive status and fecundity, population age structure and also the incidence of disease in a cat population.

PAPERS IN PREPARATION

Results of the above research are currently being prepared for publication. The titles are given below:-

Relative acceptability of bait materials to cats. Algar, D., Sinagra, J.A. and Leftwich T.D.

A technique, using cafeteria trials, to assess feral cat bait preferences. Algar, D. and Sinagra, J.A.

BIOMARKER TRIALS

Introduction

Biomarker trials were conducted to find two oral markers for the examination of bait uptake, using two bait medium types, in a feral cat population (see Baiting Effectiveness: Field Trials). A literature review suggested that three biomarkers:- Rhodamine B; Tetracycline-HCl and Fluorescein-complexone were potentially suitable labels. It was necessary to validate these biomarkers in pen trials prior to their use in the field experiment. Selection of suitable markers was dependent upon the binding site of the label, ability to detect the marker, and avoidance of possible taste aversion as a result of incorporating the biomarker in the bait.

Methods

Study Design

A review of the literature indicated the range of biomarker dose rates used and retention times (Evans and Griffith 1973; Ellenton and Johnston 1975; Johns and Pan 1981; Morgan 1981). Further extensive trials, to examine optimum biomarker dose rates and maximum retention times, were not pursued because of the limited number of cats that could be adequately housed. Rather, a standard biomarker dose was used and three cats were used as replicates for each biomarker. A further six cats (3 tetracycline

+ rhodamine, 3 tetracycline + fluorescein) were fed two biomarker combinations six days apart. The biomarker combinations were examined because it has been suggested that tetracycline may inhibit labelling by other biomarkers (Johnston *et al.* 1989).

Biomarkers and Baits

The biomarkers were incorporated into the two bait mediums to be used in the baiting effectiveness trials:- a roo meat bait and pussoff + "digest". Rhodamine B (200 mg) was inserted into a pocket cut in the roo meat. Fluorescein (200 mg) was added to roo meat in the same manner. Tetracycline-HCl (200 mg) was incorporated into the pussoff bait. Each pussoff bait was microwaved and then cooled to make it malleable and allow addition of the tetracycline into the bait matrix. The baits were then remoulded.

Study Animals

Semi-feral cats were collected at a rural rubbish tip. Thirty wire cage traps, baited with mullies (herring), were placed in areas where cat activity was most concentrated. Fifteen cats (6 female, 9 male) were captured over a two day period. A further three animals were collected as controls; these cats were shot and then frozen to await dissection.

Animal Housing

The cats were transferred, in the cages in which they were captured, to a local cattery. The cats were individually fed the labelled baits while in the cages. All cats readily accepted the treated baits. They were observed for a further two hours to make sure none of the bait was regurgitated. The cats were then released into the designated enclosure. Five enclosures were used to house three cats per treatment. Each enclosure was weather-proof and measured 2 x 6m. Large packing boxes filled with newspaper provided areas in which the cats could shelter and hide. The enclosures were cleaned daily and the cats were fed a variety of fish and tinned cat food. Fresh water was also supplied daily.

Biomarker Analysis

At the completion of the trial periods, 10 days for the cats fed a single label and 16 days for the animals fed two labels, the cats were euthanased by a veterinarian. The carcasses were frozen and transported to the laboratory. The biomarkers used have been reported to label internal tissues and also produce fluorescence in tooth dentine.

The internal organs of each cat were examined, in a darkroom, for fluorescence using a long-wave (365 nm) ultraviolet light source. Tooth dentine was examined according to the methodology discussed by Ellenton and Johnston (1975) and Johnston *et al.* (1989). Transverse canine sections were taken below the gum-line. A minimum of 3 sections per tooth were used and if necessary all canines were examined.

All tissue samples from the experimental animals were compared to those of the control cats.

Results

Internal Organs

The liver and gall bladder effectively bound rhodamine B and tetracycline. Livers of rhodamine B fed cats produced a brilliant orange - yellow fluorescence. The rhodamine B fed cats also displayed a significant marking in adipose tissue, in particular around the gut. Fluorescent traces of the dye were also found around the mouth and ears. Cats that consumed tetracycline produced a yellow - green fluorescence in the liver.

The staining of the livers labelled, varied from a smooth very bright to a patchy or punctate appearance. From either of these observations recovery of the marker was favourable. It was observed that the colour of Fluorescein - complexone under UV light was similar in appearance to that of Rhodamine B. Fluorescein - complexone bound to the liver, although incorporation was limited which resulted in loss of integrity and recovery of the biomarker.

In the treatments where cats were fed two biomarkers, only the tetracycline/rhodamine combination could be distinguished. The fluorescence produced by tetracycline tended to mask that of fluorescein in the second treatment group.

Canines

The presence of tetracycline was verified in the analysis of the canines. However, fluorescence of canines in rhodamine and fluorescein fed animals was less favourable. Faint, not easily discernible lines were observed in two of the three rhodamine fed cats and only one of the fluorescein fed animals. In biomarker combination treatments only the presence of tetracycline could be verified.

Discussion

Rhodamine B and tetracycline-HCl have been found to be useful for long-term labelling studies. Results from this biomarker trial indicated that rhodamine B and tetracycline-HCl could be used in combination, as oral markers, for the examination of bait uptake. Consumption of a roo meat bait labelled with rhodamine would result in discernible fluorescence in a number of body tissues. Uptake of tetracycline labelled pussoff baits, on the other hand, would produce distinct marking of the liver and gall bladder and could also be verified through fluorescence in canines. Consumption of the two bait types could also be verified because of the different fluorescences produced.

Results of the baiting effectiveness trial (see Baiting Effectiveness: Field Trials) suggested that cats displayed an aversion to consuming cyanide capsules coated with digest after they had consumed the pussoff baits labelled with tetracycline. Previous cyanide transects, using digest as a lure, had proved very successful in collecting cats. These results suggest that although cats may have been attracted to the cyanide bait stations, they associated the digest attractant with the pussoff biomarked bait. A possible explanation for this reaction was that multiple takes of the baits had resulted in high levels of tetracycline being consumed, these levels being slightly toxic. Thus, there may have been a subsequent aversion to consuming anything remotely resembling this bait type. This is discussed in more detail in the section entitled Baiting Effectiveness: Field Trials.

We have since become aware of two alternatives which may prove to be useful in baiting trials. Iophenoxic acid (a-ethyl-3-hydroxy-2,4,6-triiodobenzenepropanoic acid, Aldrich Chemical Co.) has been found to label a number of carnivorous species (Larson *et al.* 1981; Baer *et al.* 1985). Recently, it has been shown that administration of 1.5 mg/kg of iophenoxic acid labelled feral cats with an elimination half-life of 107 days (Eason *et al.* 1994).

Another possible biomarker is PKH26-GL, (Red Fluorescent General Cell Linker, Sigma Chemical Company). This compound is a patented fluorescent cell linker that incorporates aliphatic reporter molecules into the cell membrane by elective partitioning. Discussion with company officials suggests this compound has considerable potential as an oral biomarker in baiting effectiveness trials.

Pen trials are planned to evaluate the value of both of these biomarkers for future baiting effectiveness trials.

BAITING EFFECTIVENESS: FIELD TRIALS (SCOPE ITEMS 3, 4 AND 8)

3. Conduct two trials of baiting effectiveness on radio-collared groups of feral cats at suitable field sites. These trials will test the effectiveness of dried meat baits used in Western Australia for fox control versus the most acceptable bait type from pen and field trials.

4. Run a similar trial as above, of the selected bait type, i.e. establish a radio-collared group of feral cats and then measure the percentage kill using the selected bait type at the fauna reconstruction site at Karroun Hill Nature Reserve.

8. Collect and store sera samples from feral cats within Western Australia, in accordance with agreed protocols.

Introduction

Control methods for feral cats have not been extensively researched in Australia. When cat control has been implemented it has generally relied on using standard fox baiting procedures. These routine procedures consist of aerial baiting campaigns (5 to 10 baits/km^2) using dried meat baits. There are however, no data on the effect of fox-baiting on cats. There is circumstantial evidence that despite susceptibility to 1080 poison, bait uptake by cats is low during existing baiting campaigns.

The aim of this initial study was to provide preliminary data comparing the effectiveness of a bait of proven acceptability from pen and field trials with the standard fox bait in killing feral cats in the field. The information gained from this study is also to be used to assess techniques and methodologies for further baiting effectiveness trials and to provide a benchmark for these studies.

Materials and Methods

Initially, it was anticipated that baiting effectiveness trials would be conducted in two areas (see Scope 3 & 4). However, time and human resource requirements restricted baiting trials to one site. As discussed with ANCA earlier in the year, the study would use biomarked non-lethal baits in preference to radio-collaring populations and aerially dropping lethal baits.

Study Site

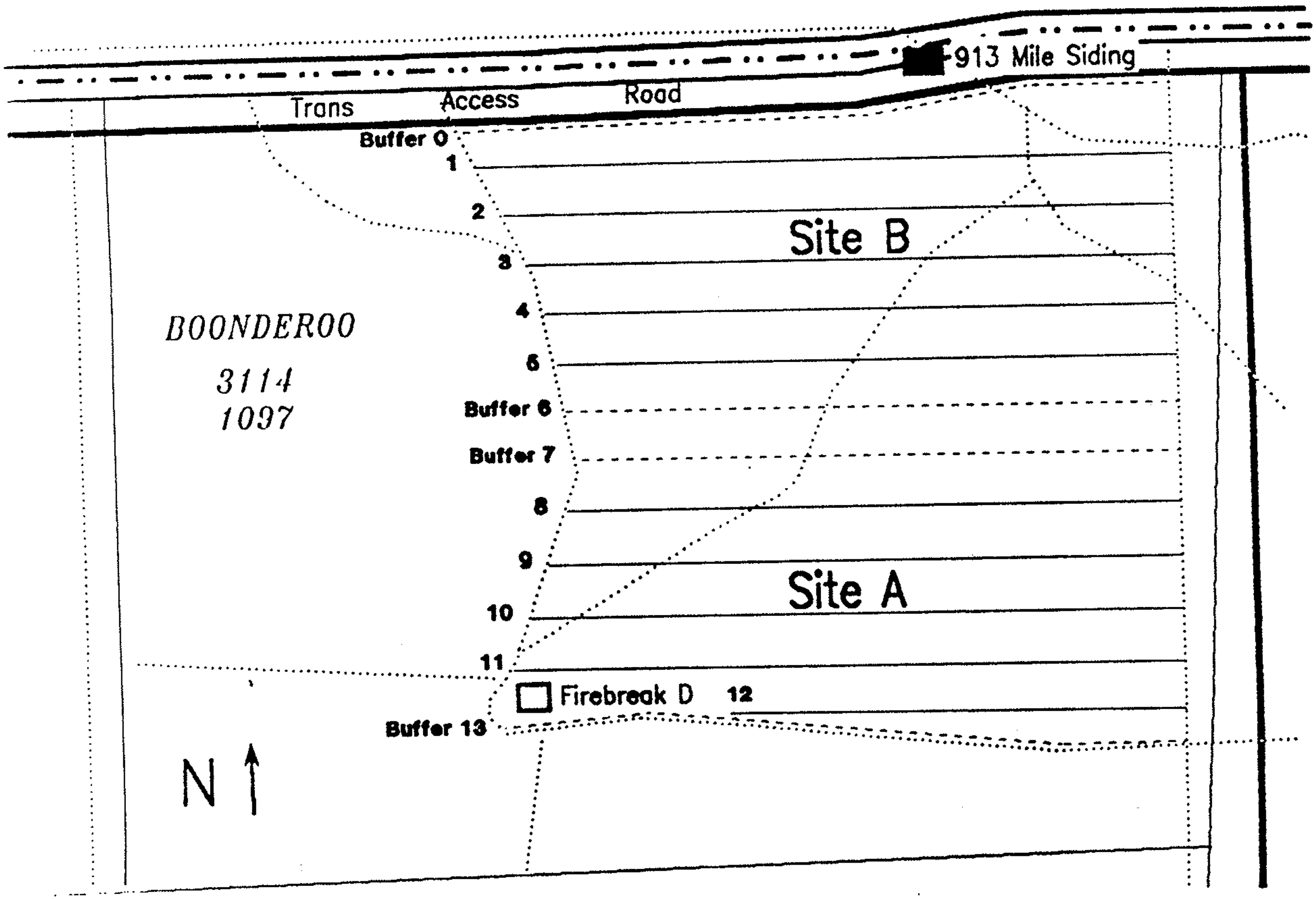
The baiting trials were conducted on the Nullarbor in Big Tree Paddock (31° 00' 44" S, 124° 42' 47" E), Kanandah Station. The area lies within the Eucla Botanical District, Nyanga Plain and is described as a lightly wooded succulent steppe (Beard 1975). Myall (*Acacia sowdenii*) was the commonest tree species in the open woodland areas, with scattered Sheoak (*Casuarina cristata*) and Rosewood (*Heterodendrum oleaefolium*). There were small areas of open bluebush (*Kochia sedifolia*) plain and more extensive perennial grassland areas of *Stipa nitida* and *Danthonia caespitosa*. Depressions or `dongas' were regular features of the area. Large areas of the site were dominated by the introduced Ward's weed (*Carrichtera annua*).

The study was conducted on an area of approximately 165 km² within the paddock. The Transline road and dingo fence provided the northern and eastern boundaries respectively. Two existing tracks within the paddock provided the western and southern boundaries of the study area. To facilitate the bait trials, 12 transects were constructed through the study area (see Figure 2). The tracks were made by dragging a set of chain harrows behind the vehicle. The transects were approximately 1 km apart, running in an east - west direction. A GPS was used to plot and navigate the transects across the paddock.

Biomarkers and Bait Types

It was not possible to use toxic baits in this study because of the threat to station working dogs. As such, a biomarker trial was conducted to find two suitable biomarkers for this study (see section entitled "Biomarker Trials", this report). The

Figure 2. Big Tree Paddock



biomarkers rhodamine B and tetracycline-HCL were selected to detect which individual cats had consumed a bait and the bait type (see below). Rhodamine B when consumed, binds in the liver and other body tissues and is clearly visible to the naked eye and fluoresces orange-yellow under UV light. Tetracycline is a bone labelling biomarker and when consumed is incorporated into the animal's tooth dentine and liver. The biomarker produces a yellow-green fluorescence, distinct from that of rhodamine.

The body cavities of cats collected, were examined for the presence of either biomarker to determine the percentage of the population that had consumed either bait type. Verification of the presence of tetracycline labels in collected cats, by examining tooth dentine, was conducted in the laboratory at the completion of field work. The effectiveness of the baiting intensity was then judged by the proportion of the population labelled.

Standard non-toxic fox baits were made in the field. The baits were cut from kangaroo meat (120g wet-weight). A pocket was cut in the baits, into which was inserted 200 mg of rhodamine. The pocket was then sealed and the baits sun-dried to approximately 40% of their original weight.

Previous pen and field trials indicated a cat preference for two bait mediums. The bait mediums were a sized reduced, moister roo meat bait and pussoff, a prototype fishmeal-based cat bait produced by Applied Biotechnologies Pty. Ltd., Melbourne. Although there was a slight bias in bait preference in favour of roo meat, it was decided to use pussoff in these trials because of limited freezer storage space.

The pussoff baits weighed approximately 20g and contained 200 mg of tetracycline-HCl. Each bait was surface coated with a "chicken digest" (5.0% w/w).

Baiting Regime

A baiting intensity of 10 baits per km^2, for both bait types, was selected as the benchmark for this initial trial. To conduct the research at a manageable level the study area was divided into two. The southern part of the study area (Site A) included transects 7 to 13, while Site B included transects 0 to 6 (see Figure 2). The length of transects 0 to 13 were 13.0, 13.0, 12.7, 12.2, 12.0, 11.8, 11.4, 11.6, 11.4, 11.5, 12.0, 11.2, 11.8 and 9.0 kms respectively.

<u>Site A</u>

Baiting commenced at site A. To mimic an aerial baiting campaign and measure bait removal over time all baits were placed on the transects. Individual bait types were located at 100m intervals, with a distance of 50m separating the two bait types. Bait preference trials had indicated that a visual attractant was important in stimulating bait uptake (see Bait Acceptability: Field Trials). Pink flagging tape, that could flap or move in the wind, anchored to a chaining arrow had proved successful in earlier trials. In this trial, the same visual attractant was used and positioned adjacent to the pussoff + digest bait/tetracycline bait. The roo meat/rhodamine bait was not flagged. A central core area of 50 km^2 (10 km along transects 8 to 12 respectively) was used to monitor bait removal. A 1 km buffer, surrounding the core area was baited as above, but not monitored. Bait removal was recorded daily.

<u>Site B</u>

To test the importance of the visual cue used in site A, no attempt was made to flag baits in site B. The same baiting intensity, using both bait types, was employed as in site A, but no baits were placed on the transect. All baits were thrown from the vehicle to land 10 to 20m distant from the transect. As such, no attempt could be made to measure bait removal in this site.

Cat Removal

Initially, it was anticipated that cyanide bait lines would be used to collect cats along the transects following examination of bait removal. Cyanide capsules as described in "Bait Acceptability: Field Trials", but containing a wire loop at one end were anchored to the ground using a roofing nail. The chicken "digest" lure was used to coat the capsule. The visual attractants used in site A were employed along the cyanide transects. Cyanide bait stations were placed at 200m intervals and left in place for three days.

A total of 50 km in site A and a further 25 km in site B was baited with cyanide capsules. Six foxes and no cats were collected using this method. None of the foxes had consumed a pussoff/tetracycline bait. The results suggested that animals displayed an aversion to consuming cyanide capsules coated with digest after they had consumed the pussoff baits labelled with tetracycline. This reasoning was further enforced when a 10 km cyanide transect was conducted along the western fence of the paddock, a distance of 5 km from the bait area. A total of four cats and three foxes was collected along this transect. None of these animals had consumed a pussoff/tetracycline bait although one cat had eaten a roo meat/rhodamine bait. As a result, cyanide transects were abandoned as a method of collecting carcasses in this particular study.

Cats were shot using 0.22 and 0.222 calibre rifles. All animals were shot at night using a 100 watt halogen spotlight to see eye-shine. The approximate location (transect number) and habitat type was noted for each kill. All cats were collected within two weeks of the bait lay to ensure integrity of the biomarker. A further eight cats were shot as biomarker controls. These cats were collected some 20 km distant from the study area.

A number of foxes were also collected from site A to determine which bait type they had consumed.

Population Biology

Cats collected were sexed and weighed. Teeth were removed for verification of the presence of tetracycline. Blood was collected for viral antibody assay. Placental scars were used to determine the number of breeding females within the collected populations and their litter size.

Dietary Analysis

Stomach contents were collected for dietary investigations. Stomachs were removed from the cats and the contents placed in plastic jars containing 70% alcohol as a temporary preservative. Stomach contents were divided into the groups:- mammal; bird; reptile; and invertebrate. Presence or absence of these categories was recorded for each cat stomach. Percentage frequency for each category was calculated as the number of stomachs containing species of the category, divided by the total number of stomachs, and converted to a percentage. Mammals and reptiles were identified to species level where possible. The mammals were identified according to hair structure as described in Brunner and Coman (1974).

Results

Bait uptake

Attempts to monitor the species responsible for bait removal at each bait location proved unsuccessful. Strong wind conditions obliterated any sign of tracks during the course of the night. Daily examination of the bait stations indicated that by day 3 the majority of baits had been removed. Those baits that remained had been covered in meat ants and the likelihood of consumption by cats or foxes was negligible. Bait removal data for roo meat and pussoff are presented in Tables 2 and 3 respectively and summarised, across transects, in Table 4.

Table 2. Daily removal of roo meat baits for individual transects.
n = 100/transect

Transect	Day 1	Day 2	Day 3	Remaining
8	70	26	2	2
9	72	18	4	6
10	75	15	1	9
11	77	14	0	9
12	83	12	1	4

Table 3. Daily removal of pussoff baits for individual transects. n = 100/transect

Transect	Day 1	Day 2	Day 3	Remaining
7	43	20	5	32
8	41	32	4	23
9	57	11	6	26
10	30	17	23	30
11	9	9	16	66

Table 4. Percentage daily removal of bait types (mean ±s.d.) pooled across transects.

Bait type	Day 1	Day 2	Day 3	Remaining
Roo meat	75.4 ± 5.0	17.0 ± 5.5	1.6 ± 1.5	6.0 ± 3.1
pussoff	36.0 ± 17.9	17.8 ± 9.1	10.8 ± 8.3	35.4 ± 17.5

Biomarker presence

A total of 35 cats was shot in the baiting effectiveness study site. The number of cats killed along each transect is presented in Table 5.

Table 5. Number of cats killed between individual transects

Transect	No. of cats
0 - 1	5
1 - 2	2
2 - 3	3
3 - 4	1
4 - 5	1
7 - 8	4
8 - 9	1
9 - 10	5
10 - 11	3
11 - 12	10

The number of cats labelled with the two biomarkers, based on fluorescence in the body cavity, for both sites is presented in Table 6. None of the cats examined was labelled with both biomarkers.

Table 6. The number of cats labelled with either biomarker for sites A and B

Site	Tetracycline label (pussoff + digest)	Rhodamine label (roo meat)	No label
A	19	1	3
B	6	0	6

Verification of the presence of a tetracycline label was conducted by examining the canines for fluorescence. Laboratory analysis indicated that only two cats had been wrongly categorised. One animal, from site A, described as labelled did not have the biomarker present in its canines, whereas one cat, from site B, that was reported with no label was verified as having the biomarker present. The actual percentage of the population that consumed either of the two bait types offered, in sites A and B, is presented in Table 6.

Table 7. The percentage of the population that consumed either bait type, for sites A and B

Site	pussoff + digest	Standard fox bait	No bait
A	78.3	4.3	17.4
B	58.3	-	41.7

Cats were observed across the study site with the exception of open grassland areas. Many of the pussoff baits remaining at the conclusion of the baiting trial were also located in these open grassland areas. Generally, rabbits had not invaded these areas and thus it is possible that reduced prey and also lack of warrens for shelter and refuge precluded cats from such regions.

A total of 33 foxes was collected from site A. The number of foxes labelled with either biomarker is presented in Table 7.

Table 8. The number of foxes labelled with either biomarker from Site A

Biomarker	No. foxes labelled	Percent sample population
Tetracycline	8	24
Rhodamine	9	27
Tetracycline + Rhodamine	15	45
No label	1	3

Verification of tetracycline labels in fox canines was not conducted. The results from analysis from cat canines suggest that examination of fluorescence in the body cavity was, in the majority of cases, appropriate for accurately determining bait consumption. Pooling the data, the results indicate that 72% of the fox population consumed a standard fox bait and 69% consumed a pussoff + digest bait.

Population Biology

Of the 43 cats collected in this trial (35 baiting effectiveness + 8 controls) 25 were male and 17 female. The weight (g) of cats collected (mean $\pm$ s.d.) was 4055 $\pm$ 1033 for males and 3377 $\pm$ 644 for females. Of interest is the fact that none of the females had produced young. In comparison, of the 16 adult females collected during the previous study at Kanandah (May 1994), only 3 animals did not have placental scars. Placental scar counts from this earlier study were 5.2 $\pm$ 1.1 (mean $\pm$ s.d.). It is generally thought that feral cats breed in the spring and autumn. The reason for lack of breeding in the spring of 1994 is hard to define. Despite the prolonged drought in the area, prey availability was still high. Although the uteri of foxes collected were not examined for placental scars, no fox cubs were observed during the study. This suggests that foxes had also not bred, or the cubs had died soon after birth.

Dietary Analysis

The contents of 42 stomachs collected in May 1994 and 34 stomachs collected in November 1994 were identified. Percentage frequencies of the major dietary categories mammal, reptile, bird and invertebrate for the two study periods are presented in Figures 3 and 4 respectively. Reptile and mammal species found the cat stomachs are listed in Appendix 1. The difference in the frequency of occurrence of the various categories between the two study periods is most likely a result of the daily activity pattern of cats. Cats were frequently observed during the day when the weather was cool in April/May. In comparison, no cats were seen during daylight hours in October/November.

Discussion

Results from this trial confirm the conclusion based on circumstantial evidence that consumption of standard fox baits by feral cats is very low. Our previous research suggested that this bait type is too large and dry to be palatable to cats.

The abundance of foxes in the study area was primarily responsible for the removal of many of the two bait types, in particular the standard fox baits. Ninety seven percent of the foxes sampled had consumed one or both of the bait types offered. The percentage of the fox population that had consumed a standard bait was slightly lower (72%) than for a previous study. In this study, in six sites across W.A., 77-88% of sampled adult foxes had taken the baits (Algar and Thomson in prep.). At Kanandah, a significant proportion of the fox population (69%) also consumed the pussoff + digest bait.

A number of factors are likely to affect bait uptake by cats. These include the bait-laying technique, type of bait, cat density, availability of other food items, and the presence of other medium-sized mammalian carnivores which may remove many of the baits intended for cats. The percentage of the feral cat population that had consumed the pussoff + digest bait with a visual attractant (78%), highlight the potential of this bait as a method of controlling feral cats.

Figure 3. Cat dietary analysis
May 1994

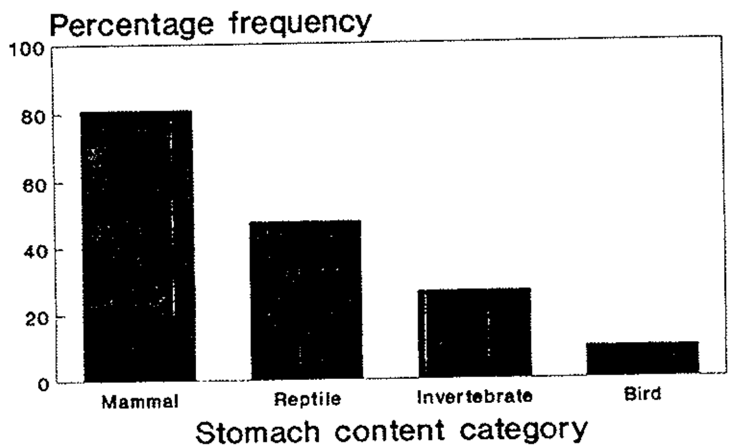
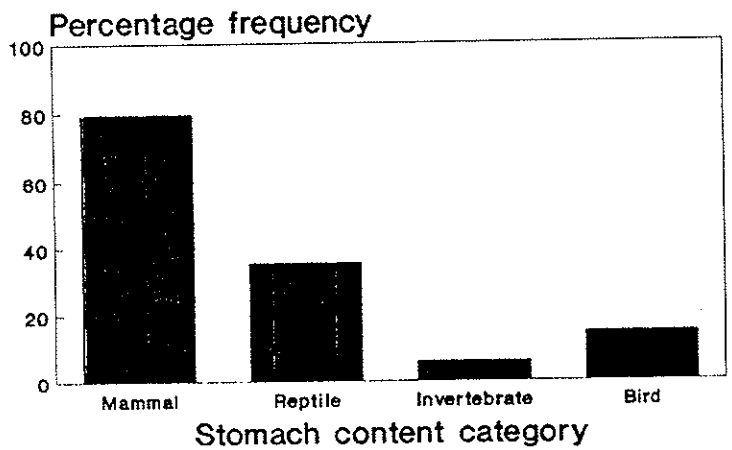


Figure 4. Cat diet analysis
November 1994



The proportion of the cat population likely to have been killed, had the baits been toxic, would have been greater than the data suggest. This is because cats are potentially able to consume multiple non-toxic baits over a number of days, thereby reducing bait availability to other cats in the area. Cats consuming multiple toxic baits are unlikely to survive more than 24 hours (McIlroy 1981).

The data suggest that pussoff/digest baits delivered at a rate of 10 baits per km^2 should significantly reduce cat numbers, at least temporarily. The longer-term effectiveness of such a baiting campaign would be reduced by immigration into baited areas. The timing and extent of this immigration would determine the frequency of baiting campaigns. The results of this initial study will provide the basis for designing and evaluating further baiting effectiveness trials (see Scope for phase 2, Broadscale control of feral cats in W.A.).

SECTION B: FOX CONTROL AT A NUMBAT RE-INTRODUCTION SITE SITE

Introduction

This project was designed to provide further data on the threat posed by feral cats to attempts to re-introduce numbats to semi-arid areas. Specifically, it involves continuation of the monitoring of re-introduced numbats at Karroun Hill Nature Reserve to determine sources of mortality under a regime of fox control using aerial baiting with standard fox baits containing 1080.

The re-introduction of numbats to Karroun Hill has been in progress since 1986. Between 5 and 20 individuals have been released there each year since October 1986 and their progress monitored by radio-tracking (Friend and Thomas in press). Dingo control by aerial baiting with 1080 meat baits was being carried out already, so no additional fox control was attempted initially. In the first two years, predation by foxes was recorded, so some fox control by baiting from the few tracks was implemented. Predation by foxes continued, so aerial baiting was introduced in 1990-1991. During those years, predation by foxes decreased, but predation by cats began to be recorded.

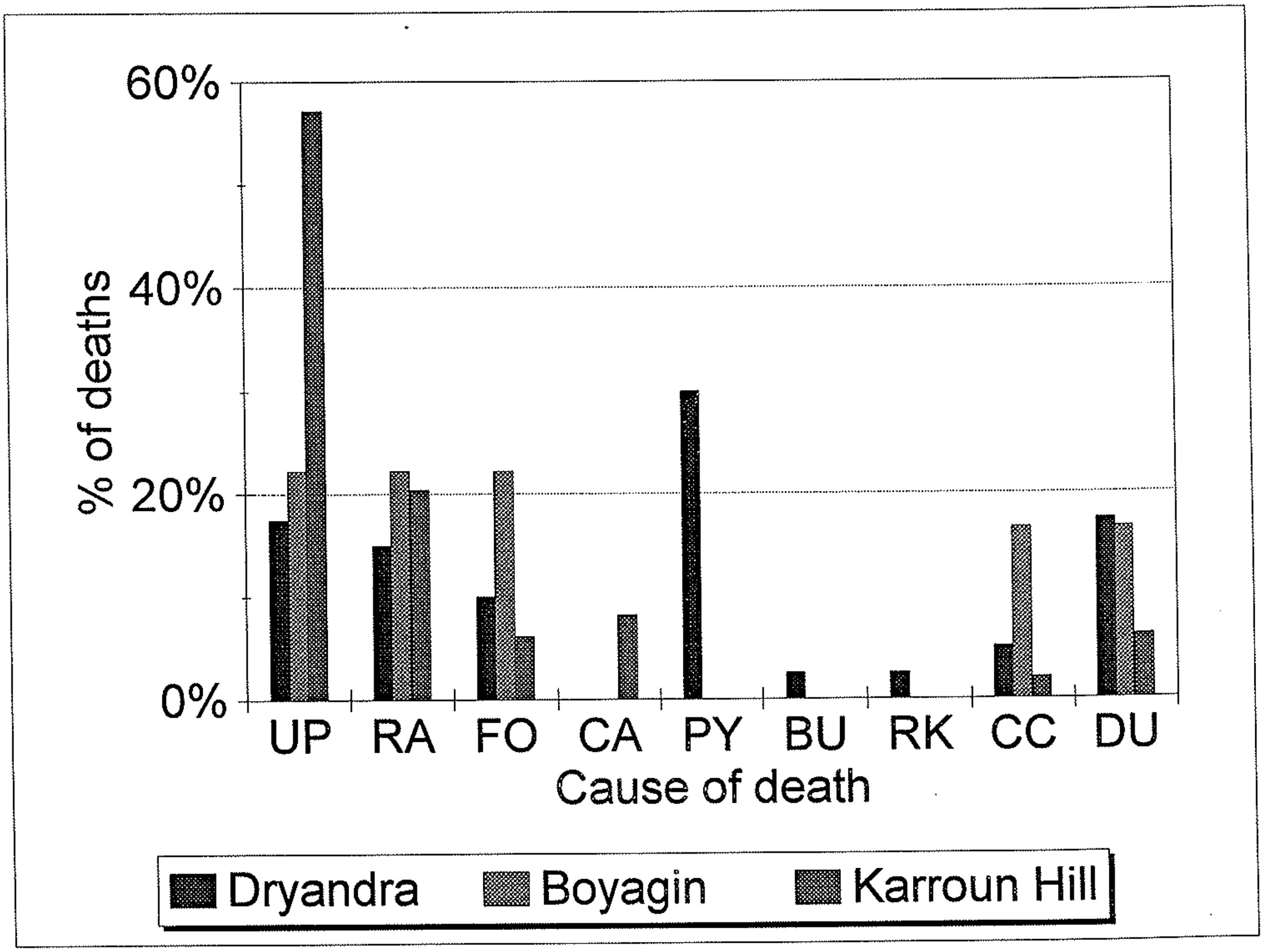
The significance of cat predation on numbat population dynamics is difficult to quantify. During the 10-year study of numbats at Dryandra and during re-introduction projects at Boyagin NR and Karroun Hill NR, cause of death of radio-collared numbats has been recorded where possible (Figure 5). Only at Karroun Hill has cat predation been definitely identified as a cause of death, albeit at a relatively low rate of occurrence. The large "unidentified predator" component at Karroun Hill in Figure 5 almost certainly includes some cat kills, and further work is now in progress to attempt to identify the responsible predator from marks left on plastic collar bands.

During work on this project with FPP funding in 1993, only three numbat deaths at Karroun Hill were recorded. One was due to a raptor and the other two to unidentified predators. However, signal loss from the transmitters fitted to another six numbats may have concealed further mortality. A new source of transmitters was used in 1994 in an attempt to decrease signal loss, on the assumption that this was due to faults in the transmitters.

During 1994 the decision was made by the Numbat Recovery Team that no further translocations to Karroun Hill would be carried out until an effective means of broadscale control of feral cats was available. This meant that there were fewer numbats to monitor at Karroun Hill. This study was assisted, however, by the capture of six young numbats at Karroun Hill in October 1993 and three young in October 1994.

Figure 5. Percentage frequency of causes of death amongst radio-collared numbats in populations studied.

UP	Unidentified predator
RA	Raptor
FO	Fox
CA	Cat
PY	Carpet python
BU	Burnt in fire
RK	Road kill
CC	Caught by collar
DU	Dead, unexplained



60%
40%
20%
0%
% of deaths
UP
RA
FO
CA
PY
BU
RK
CC
DU
Cause of death
Dryandra
Boyagin
Karroun Hill

FOX CONTROL (SCOPE ITEM 5)

5. Reduce fox numbers by aerial baiting with 1080 in an area of Karroun Hill Nature Reserve in which numbats are being re-introduced. The area, of approximately 40 000 ha, will be baited twice during 1994.

Methods

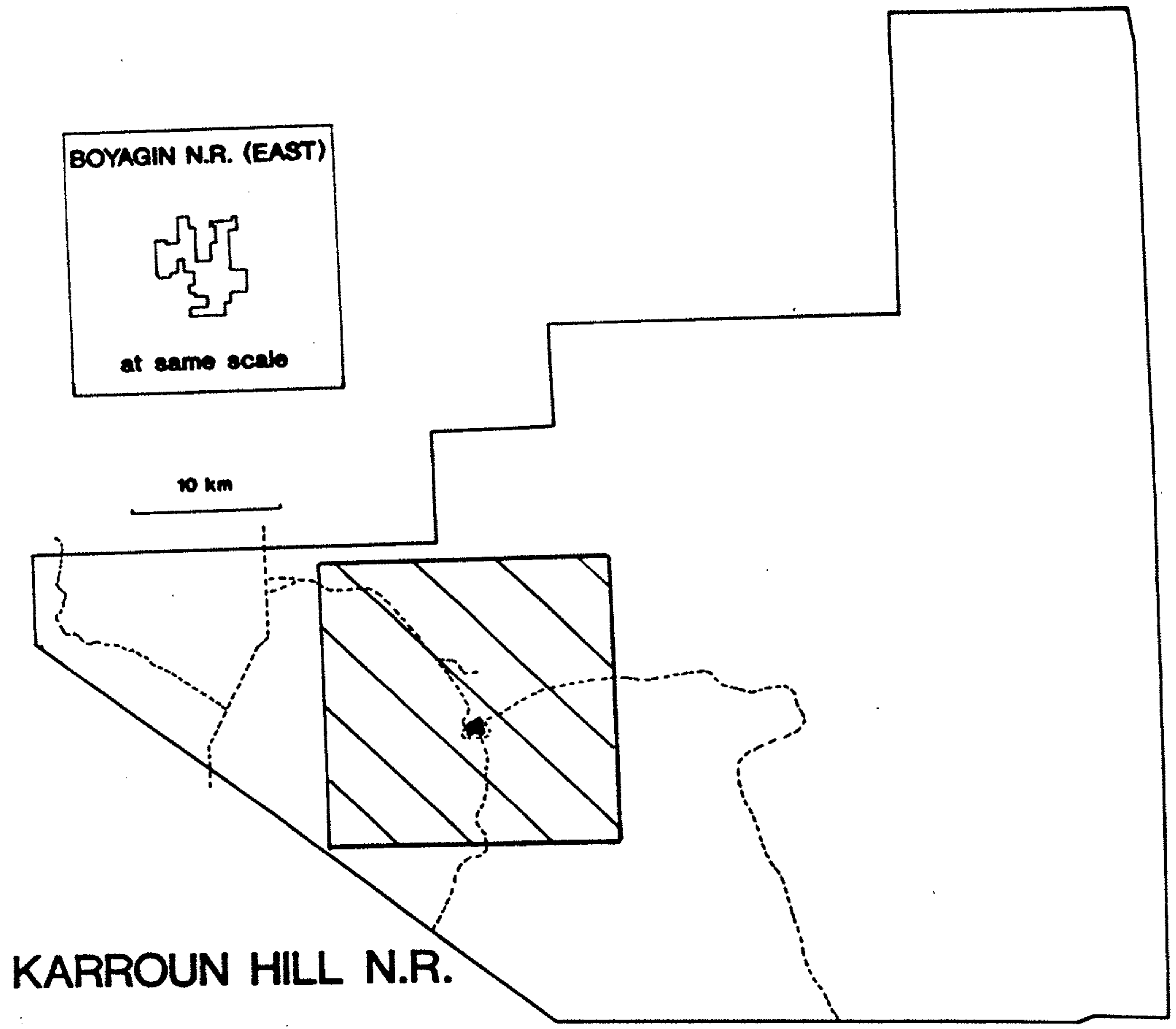
Research in the south-west of Western Australia has shown that aerial baiting using dried meat baits containing 4.5 mg of 1080 distributed at a density of 6 baits per km^2 is sufficient to kill over 90% of the resident foxes (CALM 1990) The times of year for most effective fox baiting are in September/October, before juvenile dispersal, and in March, to kill immigrant juveniles. Additional baiting during summer provides further protection as young foxes invade vacant habitat. Baiting in winter may be less effective as rain can reduce the toxicity of the baits.

The baited area is shown in the map in Figure 6. The baiting route flown follows 20 north-south lines 20 km in length separated by 1 km. The plane is kept on course by the use of a GPS unit. Baits are dropped at intervals of approximately 130 m (about every 2-3 seconds, depending on the plane's ground speed). 3000 baits are distributed over the 40 000 ha area in this manner, giving a rate of 7.5 baits per km^2.

Results

Aerial baiting was carried out on 3 May 1994 and 5 October 1994. The area of 40 000 ha (shown in Figure 6) surrounding the release site at Karroun Hill was baited at a rate of 7.5 baits per km^2.

Figure 6. Map of Karroun Hill Nature Reserve showing baited area.


BOYAGIN N.R. (EAST)
at same scale
10 km
KARROUN HILL N.R.

EFFECTIVENESS OF FOX CONTROL (SCOPE ITEM 6)

6. Monitor the effectiveness of the fox control at Karroun Hill NR using cyanide transects.

Methods

Death of foxes by 1080 poisoning is not instantaneous, and poisoned individuals can move well away from the point of bait uptake before dying. The cyanide transect method was developed to provide an index of fox density (Algar and Kinnear 1992). This technique was used in the current project to assess the density of foxes remaining on the numbat release site and its surrounds after baiting.

A carcase (sheep, kangaroo etc) is dragged along the track where the cyanide line is to be laid, to provide a scent trail. Sealed wax capsules containing 1 gm of powdered sodium cyanide mixed with an anti-caking agent are attached by wire traces to metal plates of 10 cm diameter buried 10 cm deep in the track in the scent trail. These cyanide capsules are laid along the track at 200 m intervals, two at a site, and covered with one of two bait materials: condensed milk and icing sugar on one capsule and an ox liver and blood homogenate on the other. These capsules are laid as late as possible before dark and are checked and removed soon after dawn the following day to minimise risk to diurnal non-target animals. Foxes taking the baits generally die within a few metres of the bait station. Tracks of animals investigating the baits can be seen in the sand or soft soil at the bait station. An impression can then be gained of the activity of animals that have not taken baits.

The effectiveness of the aerial baiting in removing foxes from the numbat release site was measured by the use of cyanide transects run on the nights of 31 January, 1 and 2 February 1995. This followed the previous aerial 1080 baiting by four months. Two cyanide transects each 5 km in length were laid in this way along tracks within the baited area at Karroun Hill. Transects of 10 km total comprising a total of 52 bait stations were thus run on all three nights.

Results

No foxes, cats or dingoes were killed on the transects, and no sign of foxes or dingoes was seen on the tracks where cyanide transects were laid, but a few cat footprints were seen several metres from one bait station on the second morning. During the cyaniding field trip (31 January-3 February 1995), a feral cat was sighted in daylight on one of the tracks, inside the aerial baiting area but off the cyanide transects.

NUMBAT MONITORING (SCOPE ITEM 7)

7. Monitor the numbat colony at Karroun Hill and determine sources of mortality (allocated to raptor, fox, cat, or other) in 1994 for comparison with previous years.

Methods

All numbats released at Karroun Hill are fitted with radio-collars. Each collar contains a two-stage transmitter (AVM P2-1V or Biotrack TW-2) powered by a 1.5V Hg675 mercury cell, giving a life of 4-6 months and a ground-ground range of 300-1000 m. An aircraft (Cessna 172 or 182) fitted with a side-looking 4-element Yagi antenna on each wing, giving a sideways range of 3-5 km in each direction, is used to locate dispersing numbats and to check for other transmitters not located in ground searches. The release site is visited each 6-8 weeks and the numbats are located on the ground. Their survival or mortality is noted and if possible the animals are caught, weighed, measured, condition and breeding status noted and transmitter battery replaced if necessary. If the animal is dead, all evidence which might identify the cause of death is collected or recorded. The plastic-covered collars retain some marks and scratches and an attempt is now being made to obtain more specific information on the identity of the predators responsible for these deaths, by presenting similar collars to cats, foxes and raptors in captivity.

Results

In December 1993, four numbats were translocated from Dryandra to Karroun Hill NR. At that time there were three radio-collared adults already present, and six young born at Karroun Hill had been fitted with radio-collars in October 1993.

Figure 7 shows the number of radio-collared numbats known to be alive at Karroun Hill at the beginning of each month during 1993 and 1994. Table 9 summarises the number of additions and losses of live numbat/functioning transmitter units at Karroun Hill during 1993 and 1994

Table 9. Status of live numbat/functioning transmitter units at Karroun Hill in 1993 and 1994.

Status	Number	
	1993	1994
Working Jan. 1	10	10
New units during year	11	3
Still working Dec. 31	10	3
Lost during year	8	10

Table 8 shows the fate of the live numbat/functioning radio-collar units lost during 1993 and 1994. In 1993 the largest group comprised those animals whose signals were lost. This highlights an apparent problem with the transmitters that were being fitted to numbats until early 1993. An unprecedented rate of loss of signal was experienced during 1992 and 1993 and consequently another manufacturer is now being used to provide transmitters for this study. In 1994, the most important category of cause of loss was unidentified predator. It appears that the signal loss problem was rectified by changing transmitter manufacturers, but this improvement revealed the high rate of predation that was occurring. Unfortunately only one of the predation events could be definitely allocated to a particular species of predator. Of the six deaths allocated to "unidentified predator", however, three were apparently due to a mammalian predator (fox or cat) rather than a raptor.

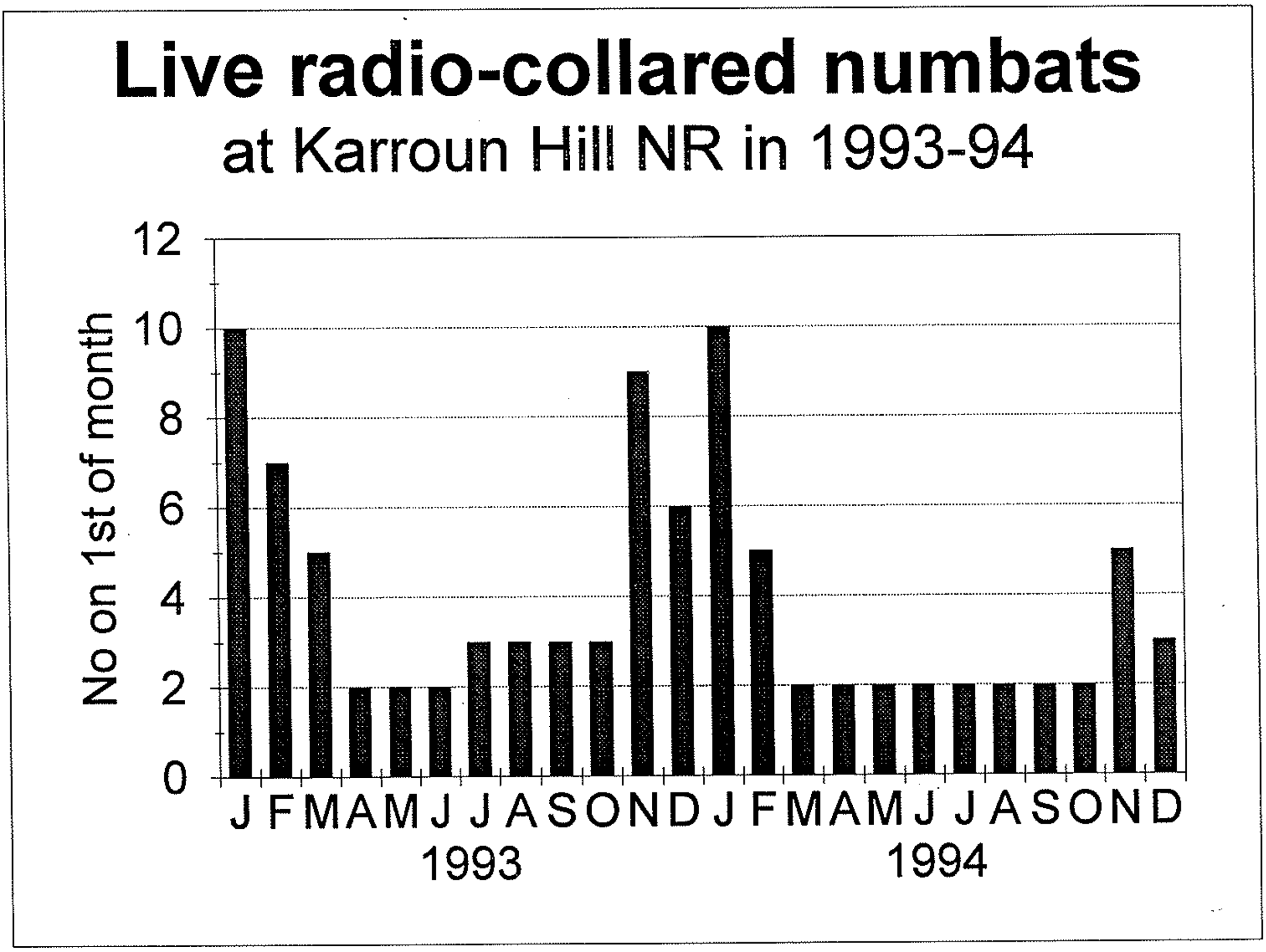
Table 10. Fate of live numbat/functioning transmitter units lost at Karroun during 1993 and 1994.

Fate	Number	
	1993	1994
Signal lost	7	3
Unidentified predator	0	3
Unidentified mammalian predator	3	3
Raptor	1	1
Total	11	10

Discussion

The aerial baiting carried out at Karroun Hill NR presented no problems of logistics. It was also shown to be very effective, possibly in combination with other baiting being carried out, in removing foxes from the area. Before the first aerial baiting was carried out in September 1990, cyanide transects on two tracks resulted in three foxes being killed. After aerial 1080 baiting, transects along two different tracks killed no

Figure 7. Number of live radio-collared numbats at Karroun Hill at the beginning of each month in 1993 and 1994.


Live radio-collared numbats
at Karroun Hill NR in 1993-94
No on 1st of month
0
2
4
6
8
10
12
J F M A M J J A S O N D J F M A M J J A S O N D
1993
1994

foxes, and no fox sign was seen. Although the track system in the reserve is very sparse, making survey by sightings unreliable, cats appear to be in genuinely low numbers in the area. A greater presence of cats might be anticipated, given the experiences of workers in other areas (Shark Bay, Gibson Desert, Tanami Desert) who recorded sharp increases in cat numbers following fox baiting.

Fox control has been carried out at Karroun Hill during this project at various intensities since 1988, and it might be expected that if a strong increase of cat numbers were going to occur, it might have begun by now. Given the effectiveness of the aerial baiting for foxes shown by the results of cyanide baiting, it appears that the persistent loss of numbats to mammalian predators (Table 10) is due to cats, not foxes. Although cat numbers appear low, the significant level of cat predation on numbats recorded at Karroun Hill underlines the need for cat control as well as fox control to reduce mortality in the numbat population. This is especially true in the light of experiences in the Gibson Desert and Tanami Desert, where small numbers of cats were responsible for great damage to re-introduced marsupial populations (Burrows *et al.* in press).

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Appendix

Category and species list of cat stomach contents for Kanandah (number of stomachs containing remains of each category or species).

	April/May (n=42)	Oct/Nov (n=34)
Bird	4	5
Invertebrate	11	2
Mammal	34	27
Macropus rufus	1	-
Mus musculus	16	1
Oryctolagus cuniculus	17	26
Ovis aries	3	-
Reptile	20	12
Dragon		
Ctenophorus reticulatus	3	-
Pogona nullarbor	4	2
Tympanocryptis lineata	15	2
Gecko		
Diplodactylus granariensis	-	1
D. pulche	-	1
Gehyra spp.	-	2
Heteronotia binoei	1	-
Underwoodisaurus mili	5	-
Skink		
Ctenotus schomburgkii	2	-
C. ube	3	-
Egernia inornata	-	1
Eremiascincus richardsonii	3	1
Lerista picturata	-	1
Tiliqua rugosa	2	-
Blind snake		
Ramphotyphlops spp	-	3
Elapid snake		
Notechis spp.	1	-