Assessment of Bait Acceptance by Introduced Predators from a Single Aerial Deployment of Bio-marked Baits in the Gascoyne Region, Western Australia.

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Introduction

Through funding from the Wind Over Water Foundation, the Department of Conservation and Land Management is conducting a series of field experiments aimed at maximising the efficiency of aerial baiting for feral cats. The relative efficacy of various baiting regimes are to be compared by the aerial deployment of non-toxic baits containing the biomarker Rhodamine B (RB). Subsequent trapping and examination of both target and non-target animals will be conducted to determine the proportion of these populations that have consumed bait material. The first study in this series was conducted at the Gibson Desert Nature Reserve and compared the relative efficacy of 50 and 100 baits per km^2 (Angus *et al.* 2002). Both the relative efficacy and the potential risk to non-target fauna of these two regimes were assessed concurrently. The efficacy and efficiency of the baiting regimes examined was comparable to that achieved previously with this bait medium and outstanding in contrast to alternate control methods and bait media employed elsewhere. The 50 baits per km^2 regime was found to be as equally efficacious as the 100 baits per km^2 regime, for the control of feral cats. The importance of prey abundance to bait acceptance by feral cats was further clarified. However representation by female cats in the sample population was insufficient for statistical comparison of the two regimes, for the control of female cats. Potential explanations for the under-representation of females were discussed. These included disturbance (by fire and previous control efforts) and the sampling methodology employed. It was hypothesised that sampling at not more than 2 km intervals, in an area not previously disturbed by fire or control regimes, would achieve a better representation of female cats (Angus *et al.* 2002). This document describes an exercise aimed at assessing a single aerial baiting regime of 50 baits per km^2. The study area has not been recently disturbed by fire or broad-scale efforts to control feral cats.

Method

Site Description

This study was conducted on the northern and western portions of Pimbee pastoral lease. Pimbee is located approximately 190km SE Carnarvon and 90km SW Gascoyne Junction, by road (Figure 1). The lease was purchased by the Department in 2001 through funding by the National Reserve System Program of the Natural Heritage Trust. The lease is to be managed for the purposes of conservation (see McNamara *et al.* 2000). The study site is dissected by linear and convoluted sand dunes, 10-20 m in height, with broad swales and interdunal plains. Dunes are of red-orange Quaternary aeolian sand (Hocking *et al.*, 1987). Dune crests (Plate 1) are vegetated by low woodlands of *Acacia anastema* with a sparse mid-storey of *A sclerosperma* and *A ramulosa* over wanderrie grasses (generally *Eriachne spp* and *Eragrostis spp*). Swales (Plate 2) are vegetated by dense to moderately dense tall shrublands dominated by *A ramulosa*. Scattered emergents include *A pruinocarpa* and *A aneura*, associated shrubs include *Ptilotus obovatus*, *Senna helmsii* and *Eremophila spp* over wanderrie grasses. Payne *et al.* (1987) provide a more complete description of the landforms and vegetation at the study site.

Figure 1. Study site location.

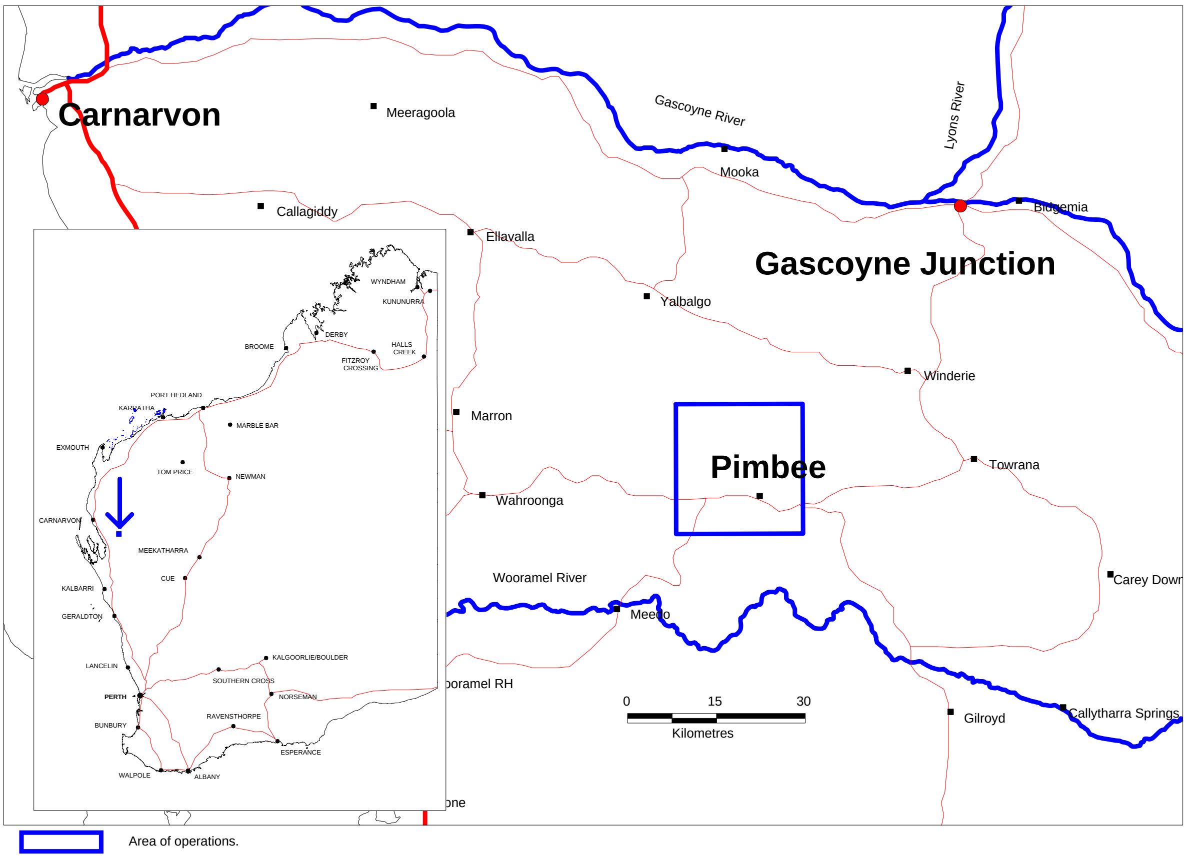


Plate 1. Dune crest with low woodland of *Acacia anastema*. Photo – B. Withnell.

Plate 2. Interdunal plain with dense shrubland of *Acacia ramulosa*, here with emergent *A pruinocarpa*. Photo – B. Withnell.

Plate 3. Overlooking a broad interdunal plain. Photo – B. Withnell.

Bait Medium and Distribution

The bait medium used was the kangaroo meat sausage described by Angus *et al.* (2002). Each bait contained approximately 15 mg Rhodamine B (RB). Preparation of baits differed from that for the previous study in that weather conditions allowed for thorough 'sweating' of the baits, prior to deployment. On distribution, oily portions of the bait material had exuded through the sausage skin to coat the external surface of each bait.

Baits were distributed from a Beechcraft Baron aircraft using the navigation system described by Angus *et al.* (2002). A single bait distribution was conducted over the target area (Figure 2) at a rate of 50 baits per km^2. Bait distribution differed from that described by Angus *et al.* (2002) in that baits were not evenly spread over each baiting cell. Instead, all baits for each cell were delivered to the bait tube as quickly as possible, at the start of each cell. Therefore it is assumed that baits were clumped at 1 km intervals, rather than 'evenly' distributed across each cell.

Predator Trapping

Trapping for predators was conducted between 17 and 26 March 2002. Trapping methodology follows that of Angus *et al.* (2002) and trap locations are indicated by Figure 2. Traps were placed at 500m intervals, along transects of not more than 2 km intervals. The two lure systems – Pongo only and audio + Pongo – were employed at alternate 500 m intervals along each transect (see Figure 2). As existing vehicle access was insufficient to allow transects at 2 km intervals, Suzuki 300cc ATVs were used to access transects where no vehicle access was available. A total of 1381 trap nights was conducted and Table 1 indicates the dates of commissioning and decommissioning of trap sets.

Table 1: Dates of commissioning and decommissioning of predator traps.

Trap Numbers	Commissioned	Decommissioned	Trap Nights
L701-L725	16/03/2002	25/03/2002	225
L601-L625	16/03/2002	26/03/2002	250
L501-L525	17/03/2002	26/03/2002	225
L401-L425	18/03/2002	26/03/2002	200
L301-L318, L201-L216	19/03/2002	26/03/2002	238
L319-L325, L217-L225, L101-L122	20/03/2002	26/03/2002	228
L123-L125	21/03/2002	26/03/2002	15
		Total	1381

Figure 2. Location of baiting area and predator traps.

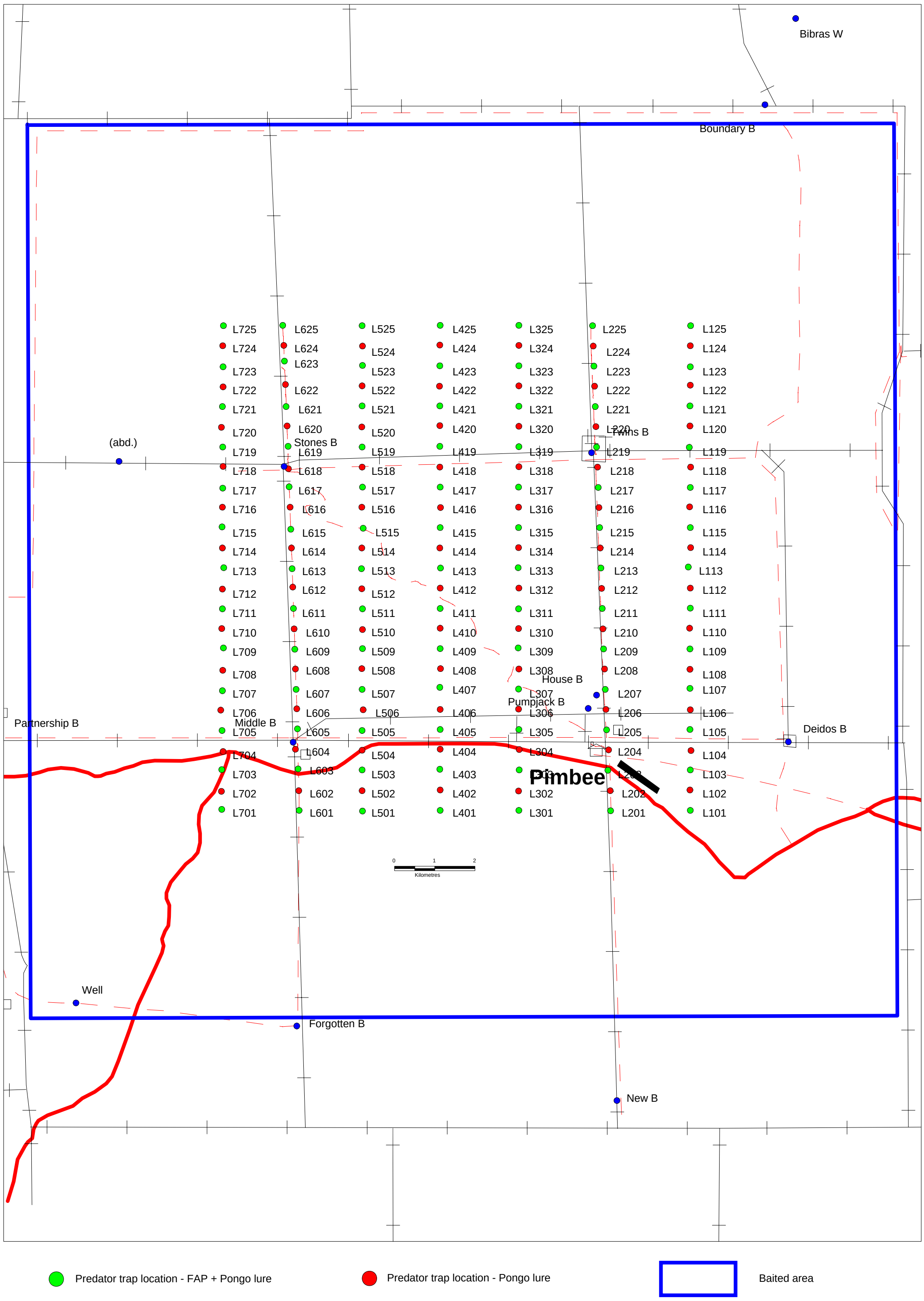


Plate 4. Trapping coordinates were generated with GIS software and downloaded to GPS receivers mounted on the vehicle. Photo – J. Angus.

Necropsies and Sample Analysis

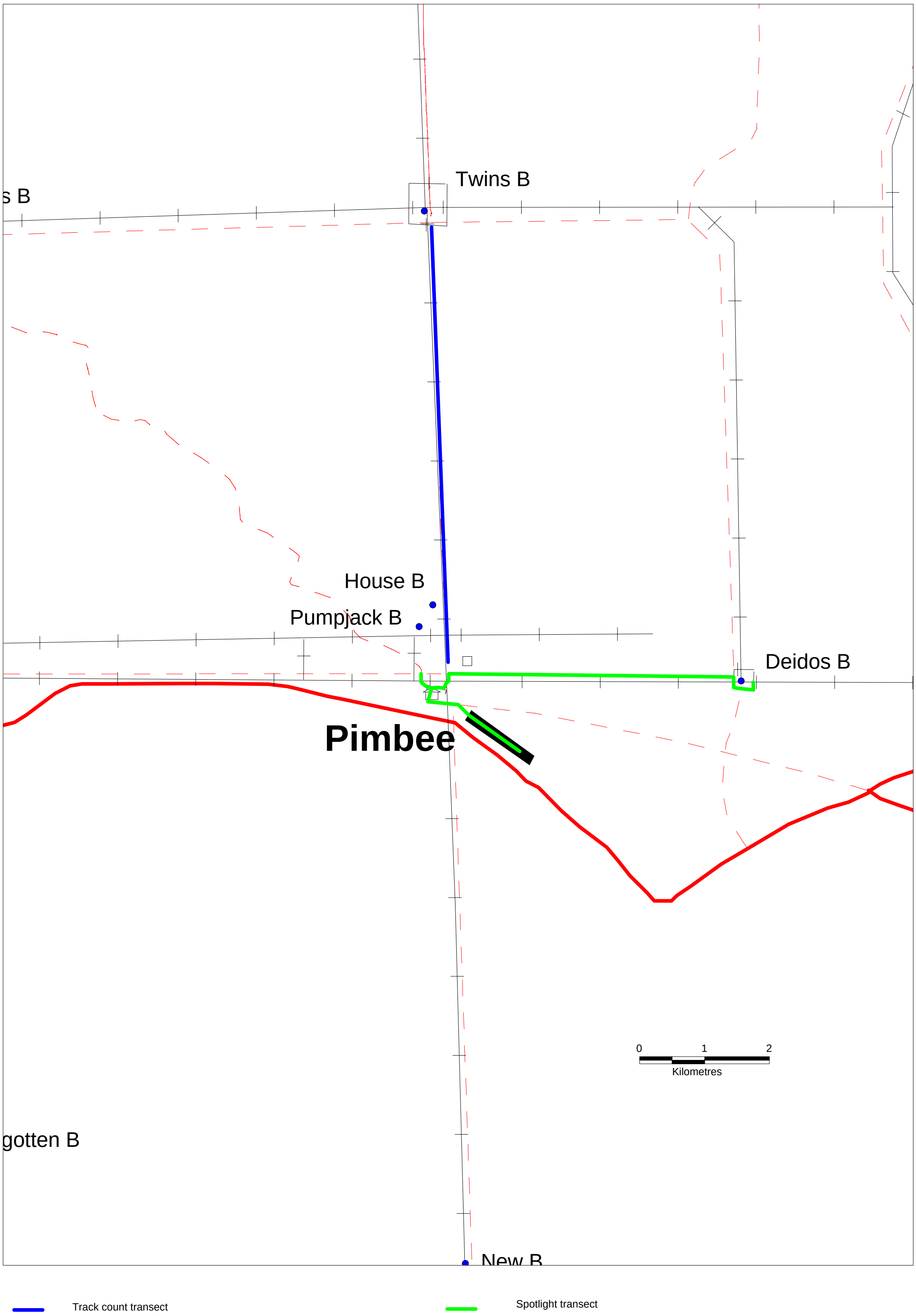
All captured animals were shot in the head with a .22 calibre firearm, using hollow-point projectiles. Each individual was weighed, measured and examined for reproductive activity. Stomachs were removed and stored in a 10% formalin solution before analysis of contents was conducted in the laboratory. Mystacial vibrissae were removed and examined for marking by RB under ultra-violet radiation. Methodology for sample analysis is described in full by Angus *et al.* (2002).

Assessment of Rabbit Activity

A single transect, 6.5 km in length, was established to assess rabbit activity at the study site. The location of the transect is indicated by Figure 3 and was over existing vehicle access that was clear of vegetation and had a soft, sandy substrate. Previous animal activity was removed from the transect by towing two truck tyres behind a vehicle. The following morning, the transect was examined for rabbit tracks. Tracks were counted on a 10 m section of transect, every 100 m. The number of tracks at each 10 m sample station was recorded as one, two or three or more. The transect was traversed on three consecutive mornings between 23-25 March 2002.

Further to the track count transect, a spotlighting transect was traversed on the nights of the 22 and 25 March 2002. A single 1.06 million Cd, variable beam spotlight was operated from a vehicle with three observers. The transect indicated by Figure 3 was traversed at a speed of less than 15 kmh^{-1}. The location of all rabbits observed was noted.

Figure 3. Rabbit activity transects.



Trap Interactions.

For the purpose of this study, a trap interaction is defined as any predator activity within a 5 m radius of a trap set. The presence of predator paw imprints within or near to each trap set was identified and recorded daily. Note that traps are not always triggered when a predator enters a trap set and individual animals do not always enter trap sets upon encounter.

Results

Predator Sampling

A total of 11 cats and 14 foxes was captured during the trapping exercise (Table 2). In addition to these captures, a single cat was shot, at the homestead complex on the evening of 25 March. Locations of cat and fox captures are indicated by Figures 4 and 5 respectively.

Of those cats captured during the trapping program, four (36%) were female. Conversely female foxes represented 71% of the sample population for that species.

Table 2. Summary of predator captures and physical attributes.

	CAT			FOX		
	♂	♀	Total	♂	♀	Total
Captures	7	4	11	4	10	14
Trap success (per trap night)	0.005	0.003	0.008	0.003	0.007	0.010
Mean Weight (kg ± s.e.)*	3.30 (±0.19)	2.55 (±0.09)	3.10 (±0.17)	4.20 (±0.44)	3.91 (±0.12)	3.99 (±0.15)
Mean Length (cm ± s.e.)*	50.0 (±0.89)	46.5 (±0.87)	48.8 (±0.81)	61.8 (±2.66)	58.5 (±0.89)	59.4 (±1.00)
Mean Litter Size (± s.e.)*	N/A	1.0 (0.58)	N/A	N/A	2.7 (±0.40)	N/A

Note: Fields marked * include data from the individual that was shot.

Dietary Analysis

Figures 6 and 7 indicate the dietary composition for the cats and foxes sampled. Reptiles were the most frequently occurring item in the diet of the cats sampled, present in the stomachs of 83.3% of individuals. Invertebrates were the most frequently occurring item in the diet of the foxes sampled, present in the stomachs of 64.3% of individuals. The presence of goat in the stomachs of the captured foxes appears to be a result of predation of live animals as no blowfly larvae were present to indicate feeding on carcasses.

Figure 4. Location of cat captures.

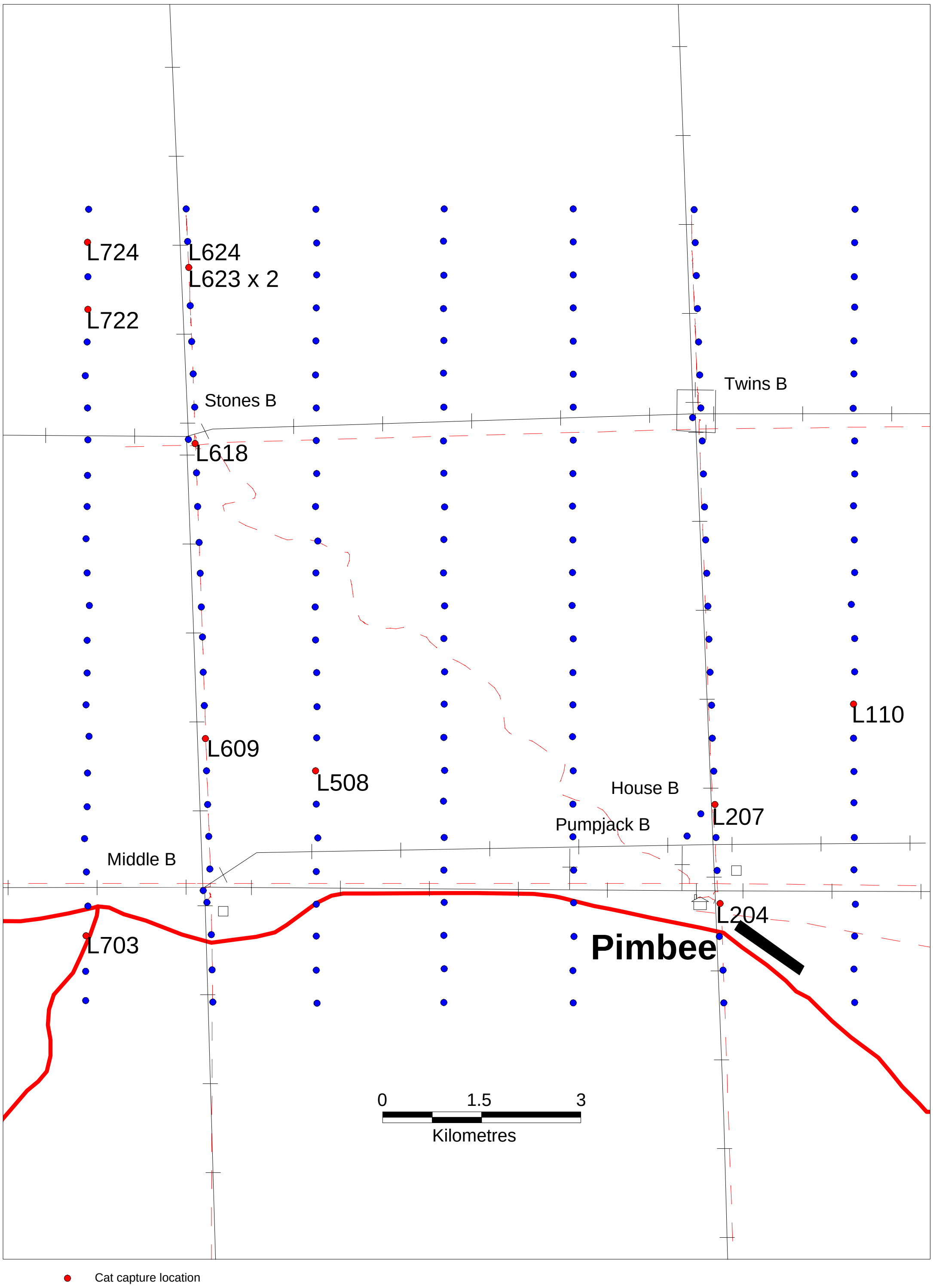


Figure 5. Locations of fox captures.

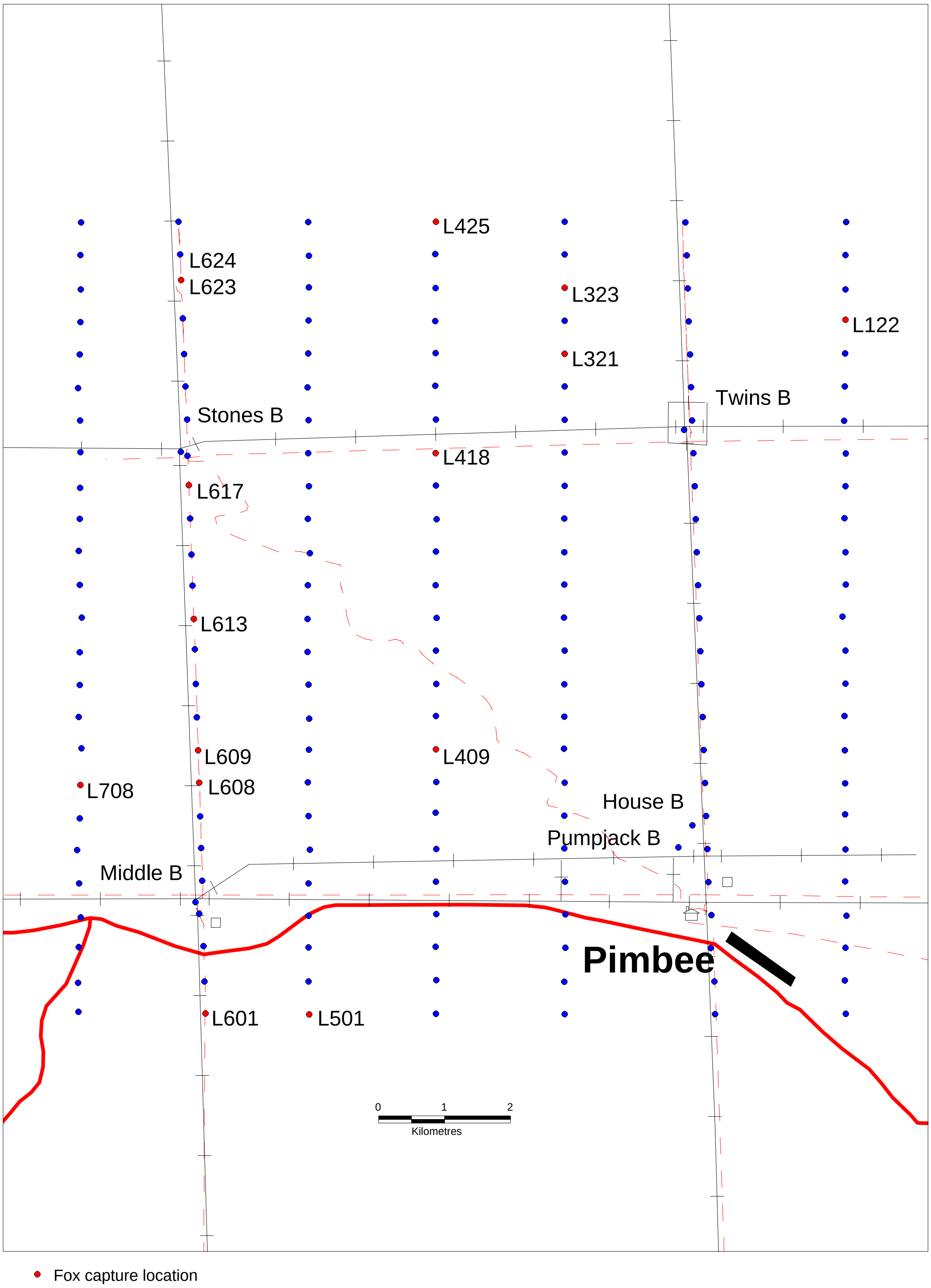


Figure 6. Frequency of occurrence of items in cat stomachs.

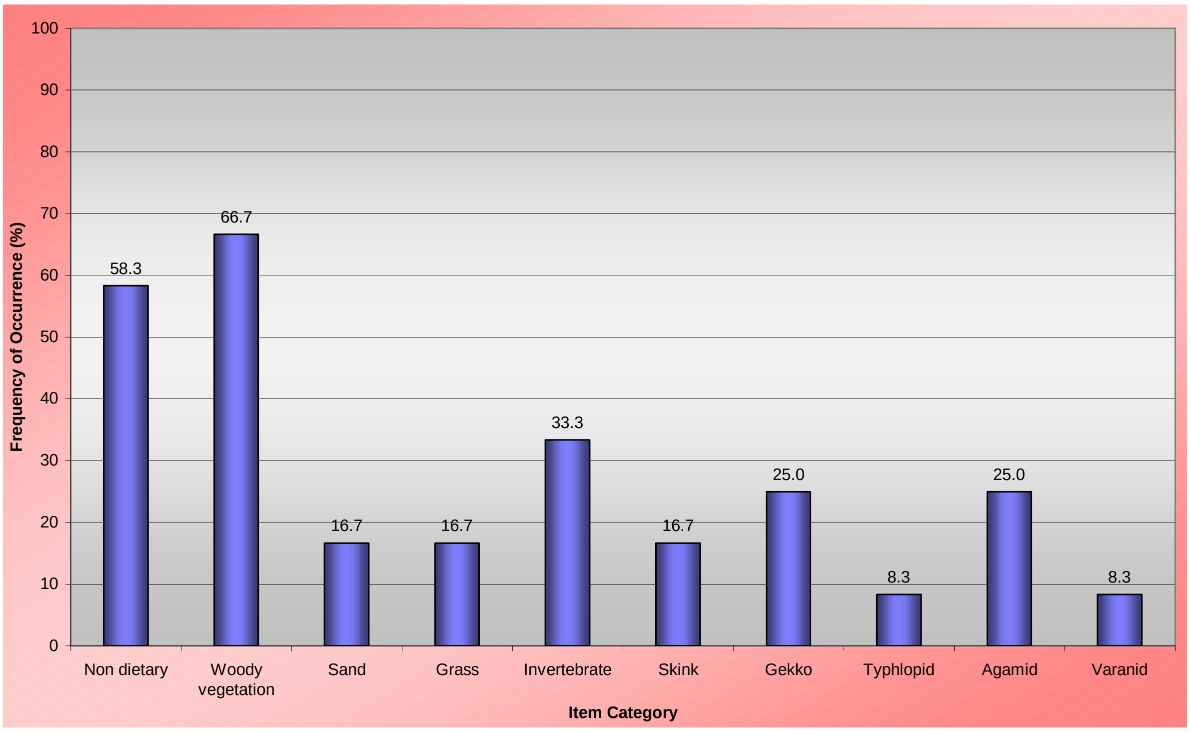
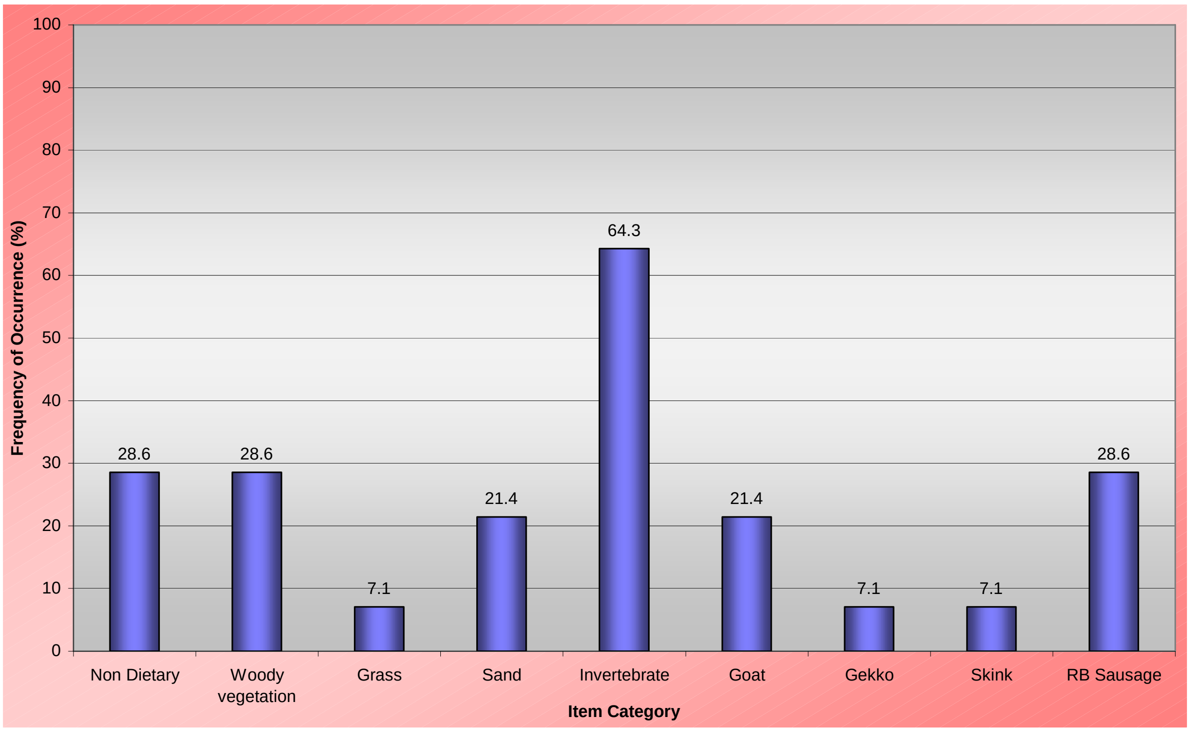


Figure 7. Frequency of occurrence of items in fox stomachs.



Marking by Rhodamine B

All cats in the sample population were marked by RB. Significantly, bait acceptance by both male and female cats was 100%.

All foxes in the sample population were marked by RB. Four individuals had bait material in their stomach, indicating that foxes were locating and consuming baits at least two weeks after they were distributed.

Rabbit Activity

No rabbit was recorded on the track count transect, during the three traverses. The only rabbits sighted during spotlight transects were within a 100 m radius of the homestead complex. At this position there was two discrete areas of activity. The first is at the shearer's quarters, 80 m west of the homestead where approximately 10 individuals were active. The second area is 100 m north of the homestead where approximately 20 individuals were active. Rabbits are absent or sparse over the remainder of the study site.

Trap Interactions

The number of trap interactions by cats and foxes is presented in Figures 8 and 9 respectively and presented as a percentage of the total number of traps in place on the particular day. Figures 8 and 9 also present the cumulative number of captures of the two predator species respectively.

There was not a strong linear relationship between the frequency of trap interactions and the cumulative captures of feral cats (r^2=0.32, F=3.82, α=0.09). There was a significant correlation between the frequency of trap interactions by cats and the number of trapping days elapsed (r^2=0.43, F=6.15, α=0.04). However cat activity (as measured by the frequency of trap interactions) essentially did not decrease after the fifth night of trapping (Figure 8).

Plate 5. Returning captures to the homestead for processing. Photo – J. Angus.

There was no significant correlation between the frequency of trap interactions and the cumulative captures of foxes (r^2=0.08, F=0.69, α=0.43). Neither was there a significant correlation between the frequency of trap interactions by foxes and the number of trapping days elapsed (r^2=0.20, F=1.97, α=0.20). Fox activity did not decrease after the fourth night of trapping.

Figure 8. Trap interactions and cumulative captures of feral cats.

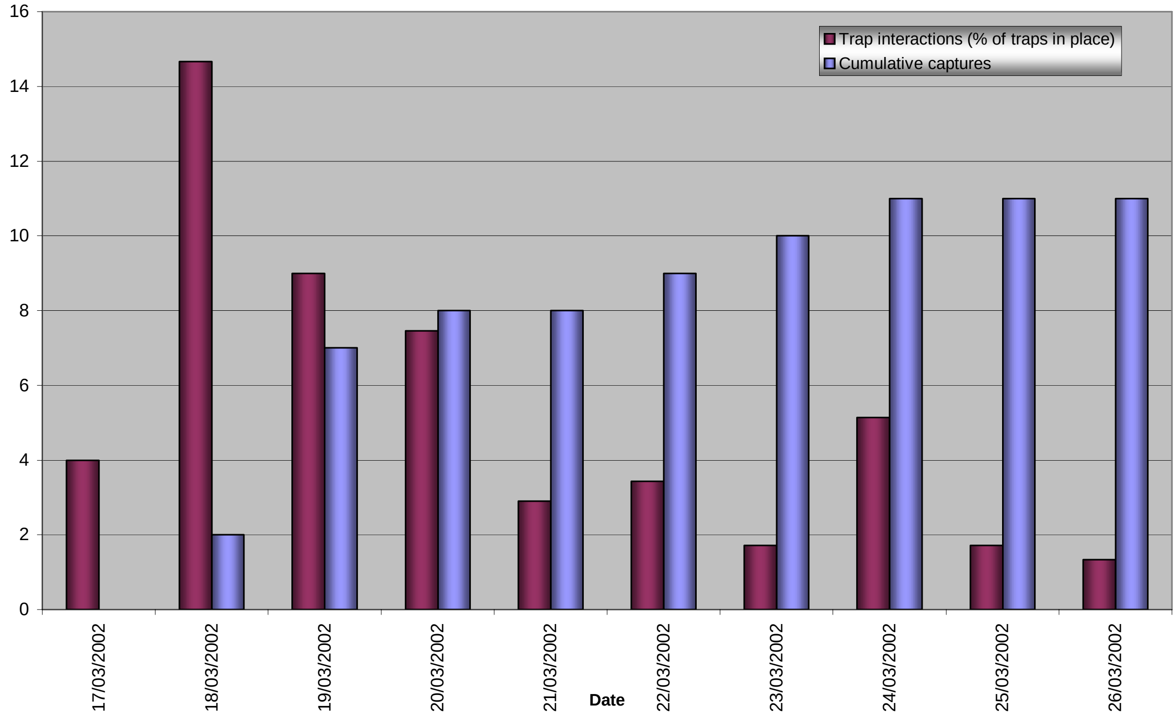
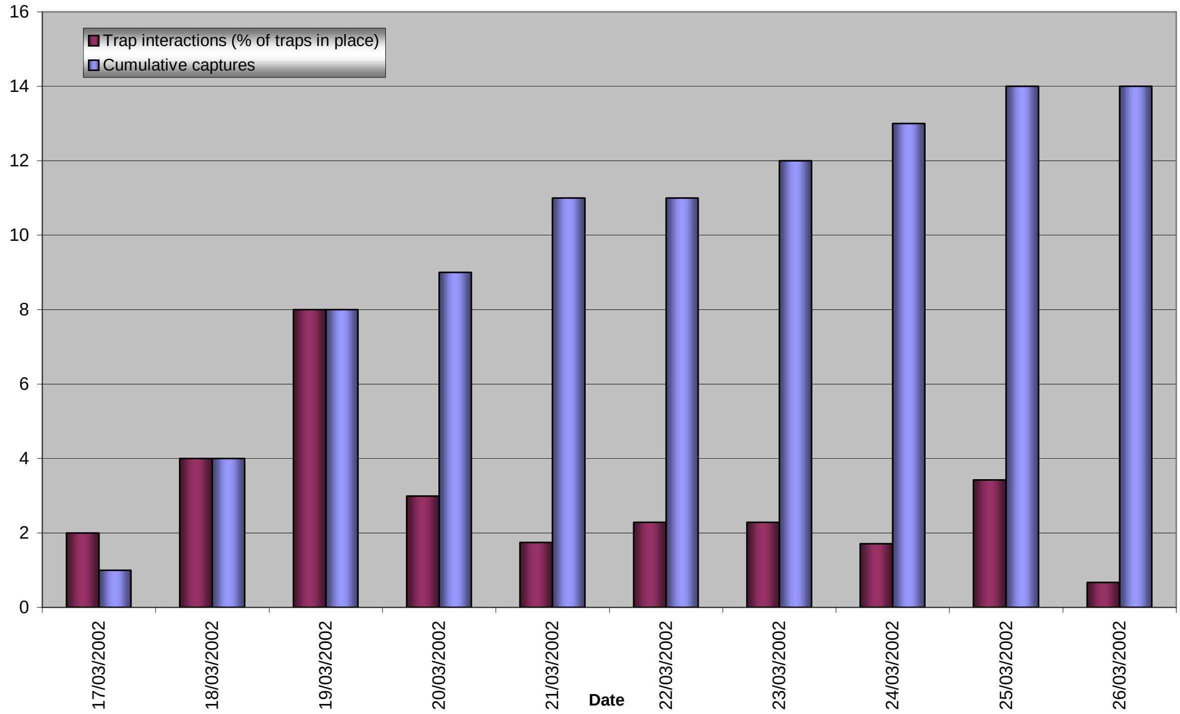


Figure 9. Trap interactions and cumulative captures of foxes.



Discussion.

This exercise confirms the efficacy of 50 feral cat sausage baits per km^2 at this location, for the control of feral cats and foxes. The level of feral cat control predicted by this baiting regime exceeds that achieved previously at the Gibson Desert (Angus *et al.* 2002). This level of potential population reduction from a once-off feral cat or fox control program is comparable to the most efficient results achieved previously in arid/semi-arid Western Australia (Short *et al.*, 1997; Thomson and Algar, 2000; Thomson *et al.*, 2000).

The high level of marking of the sample populations from this site and the Gibson Desert indicates that this density of baits is not close to the lower limit required for effective control of cats and foxes. Further significant improvement in the efficiency of aerial baiting for feral cats can be expected from investigating lower densities of bait distribution. The lower critical limit of bait density may be dependent on both the density of target animals and prey availability.

Determination of required baiting density must take into consideration the number of target individuals present and any caching behaviour that may occur (see for example Thomson and Algar, 2000; Saunders *et al.*, 1999). Density estimates for feral cats in Australia are consistently low and generally less than 1 individual km^{-1} (see Jones and Coman, 1982; Edwards *et al.*, 2001), therefore the density of the target animal is unlikely to strongly influence the bait distribution required in most locations. Little is known of caching behaviour by feral cats, however the presence of bait material in the stomachs of foxes captured during this study and its absence in the stomachs of cats, may indicate a contrast in caching behaviour (see Saunders *et al.*, 1999). A lack of caching behaviour by cats during this study may have reduced the likelihood that they located and consumed bait material immediately prior to and during the sampling period.

Availability of prey influences the probability that bait material is accepted upon encounter (Short *et al.*, 1997; Algar *et al.*, in press). When prey is in abundance, the probability that an individual cat is hungry at any given time is greater than when prey is scarce. Therefore a greater density of bait distribution may increase the probability of bait encounter at a time when an individual cat is hungry and efficacy may be improved by greater baiting density, during periods of high prey availability. However baiting with a range of bait media at very low baiting densities, during periods of low prey abundance, has consistently achieved good bait acceptance by feral cats (Burrows *et al.*, in prep.; Short *et al.*, 1997; Sinagra and Algar, 1998; Onus *et al.*, 2002). Perhaps most significantly, effective control of feral cats has been achieved with a distribution of 22 baits per km^2, using semi-dry kangaroo meat baits (Burrows *et al.*, in prep.). Several authors have suggested that baiting for feral cats is only efficacious when prey availability is low (Short *et al.*, 1997; Burrows *et al.*, in prep.; Algar *et al.* in press). Therefore the efficacy of lower baiting densities should be investigated as a priority and higher densities reserved for exceptional circumstances where species of high conservation value require urgent protection, in the presence of high prey density.

Investigation of lower baiting densities will need to take into consideration the influence of using non-toxic bait material. This practice may reduce the effective availability of bait material as individual animals are free to consume multiple baits, potentially reducing their effective availability to other individuals (e.g. Thomson and Algar, 2000). For this reason, accurate indication of the lower limit to efficacious baiting can only be determined through toxic baiting.

Investigation of the lower critical limit of baiting density will also have to consider the time elapsed between bait application and assessment of bait acceptance. Investigation of bait acceptance by foxes has indicated that baits may be not be taken by certain individuals until at least 44 days after application (Thomson *et al.*, 2000). As suggested by Thomson and Algar (2000) and Thomson *et al.* (2000), assessment of efficacy soon after bait distribution may produce an underestimate.

This study did not indicate sex bias in bait acceptance by feral cats. However despite sampling in a grid pattern at a site not recently disturbed by fire or broad-scale predator control, a bias toward the capture of male cats was again recorded. Notwithstanding other possible explanations (see Angus *et al.*, 2002) the relatively high abundance of foxes at this site may have contributed to the sex bias in the sample population of cats. The presence of foxes may select for a greater proportion of males in the underlying population or may influence cat behaviour, such that male cats are more likely to be trapped. Kay *et al.* (2000) caution against making assumptions about underlying predator populations, based upon trapped populations. The sample from this exercise did not approximate the total underlying population present (see Figure 8 and Seber, 1973), therefore conclusions drawn on the population as a whole are presented with this strong qualification. Because of inherent behavioural differences between male and female cats (see discussions by Angus *et al.*, 2002), lower baiting intensities may well produce a real sex bias in bait acceptance. Investigations of lower baiting densities must take this into consideration. A sample approximating the underlying population of the study area will give greater confidence that any biases observed are real. This is unlikely to occur when another predator species is captured with regularity. Therefore areas that support dense fox populations should be avoided for studies specifically aimed at feral cats.

The importance of rabbit abundance in influencing bait acceptance is further confirmed by this study. Rabbits were present over a very small percentage of the study site and are not important to the diet of cats or foxes at the time of sampling. Short *et al.* (1997) predicted that bait acceptance by feral cats is likely to be poor when rabbit abundance is greater than 1.2 km^{-1}, measured via spotlight transects. Spotlight counts during the present study were zero on all but several hundred metres of transect traversed.

The fox sex ratio recorded here is inconsistent with that of populations elsewhere (e.g. Kay *et al.*, 2000; Marlow *et al.*, 2000). Feral cat sampling with this technique has previously been deliberately conducted in areas of low fox abundance. Therefore there is little data with which to compare that presented here. However the lure systems used are aimed at capturing feral cats, not foxes and may well be biased toward the capture of female foxes. As activity of foxes did not decrease as sampling continued, the sample does not appear to approximate the total population present. As discussed above for feral cats, conclusions about the underlying fox population are made with the qualification that the sample obtained may be insufficient and appears to be biased. This study was not intended as an investigation of baiting efficacy for fox control. Although it appears that foxes readily consumed bait material, this can only be confirmed using techniques specifically aimed at sampling this species.

This study indicates that effective feral cat control would be achieved by distributing toxic baits in the same manner. The bait medium and method of distribution show promise for the concurrent control of foxes, however this also requires clarification.

There is potential for a significant reduction in the density of baits distributed, significantly decreasing the likelihood of non-target impact, without any reduction in efficacy. Priority for future investigations should be comparison of this baiting regime with a series of significantly lower densities. Sampling with the methodology used here, in the absence of 'disturbance' (including that by other predators) offers the best opportunity to approximate the entire underlying population, thus minimising bias in the sample achieved.

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