

A bait-suspension device for the control of feral cats

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Abstract. The use of poison baits is an effective method for controlling feral cats. However, take of baits by non-target animals may place those animals at risk of poisoning and also reduces the availability of baits to the target animal, feral cats. Therefore, techniques that reduce non-target take of baits are desirable. Earlier trials have suggested that suspending baits might prevent most non-target animals from removing the baits while maintaining their attractiveness and availability to feral cats. This paper assesses the efficacy of a bait-suspension device to provide a relatively simple means of controlling feral cats (across age and sex classes). In addition, it confirms the high target specificity of the bait-delivery mechanism on Australia's Christmas Island, where non-target species would have posed a problem with baits laid on the ground. The technique may have potential application on other islands where similar non-target species are threatened by baiting programs or at specific sites on the mainland where aerial or on-track deployment of feral cat baits may pose an unacceptable risk to non-target species.

Introduction

There is extensive evidence that the introduction of domestic cats (*Felis catus*) to both offshore and oceanic islands around the world can have deleterious impacts on endemic land vertebrates and breeding bird populations (e.g. van Aarde 1980; Moors and Atkinson 1984; King 1985; Veitch 1985; Bloomer and Bester 1992; Bester *et al.* 2002; Keitt *et al.* 2002; Pontier *et al.* 2002; Blackburn *et al.* 2004; Martinez-Gomez and Jacobsen 2004; Nogales *et al.* 2004). Insular faunas that have evolved for long periods in the absence of predators are particularly susceptible to cat predation (Dickman 1992).

Cats were taken to Christmas Island, at the time of first settlement in 1888 and a feral population became established soon thereafter (Tidemann *et al.* 1994). Initially, cats were concentrated around settlement and mining areas where they had access to discarded human food (Tidemann 1989; Tidemann *et al.* 1994). With the expansion of introduced black rats (*Rattus rattus*) across the island, feral cats became more widespread (Tidemann 1989). More recently, the presence of an abundant feral cat population in the National Park on Christmas Island and a stray cat population in the settlement has raised concerns from island authorities and the community about threats to native fauna, human health and nuisance animals. Organisations responsible for the management of Christmas Island expressed an interest in an effective and cost-efficient program being provided to control feral/stray cats on the island.

Baiting is recognised as the most effective method of controlling feral cats (van der Lee 1997; Short *et al.* 1997; Anon. 1999; Algar and Burbidge 2000; Algar *et al.* 2002; Algar and Burrows 2004) when there is no risk posed to non-target species. Previous on-track baiting exercises on the Cocos (Keeling) Islands (Algar *et al.* 2004) highlighted the potential

problem of certain non-target species removing ground-laid baits. Land crabs (*Cardisoma carnifex*), which dominate the forest floor, hermit crabs (*Coenobita perlata*), black rats and feral chickens (*Gallus domesticus*) readily consumed baits placed on the ground in that study. A 2003 pilot study on Christmas Island demonstrated that robber crabs (*Birgus latro*) as well as black rats readily removed baits laid on the ground (Algar and Brazell, unpubl. data). Bait removal by non-target species reduces the availability of bait to feral cats and therefore reduces the efficacy of their control. Trials on the Cocos (Keeling) Islands (Algar *et al.* 2004) suggested that suspending baits ~30–40 cm above the ground prevented most non-target animals from removing the baits while maintaining their attractiveness to feral cats. During the pilot trial on Christmas Island it was found that presenting baits at bait stations using a gantry device effectively prevented removal by robber crabs and rats but did not hinder their take by cats.

As a result of the pilot study, it was recommended that the control program for feral cats (i.e. those cats outside the settlement and light industrial area) should be centred on a ground-based baiting strategy with the baits suspended from a gantry device at each bait station. The bait stations would be located at 100-m intervals along the entire 122.6 km of road/track network on the island. This road/track network provides excellent coverage of the island, as most of the area is within 1 km of a road. It is likely that virtually all cats would encounter the road network during their general home-range movement patterns or as neighbouring individuals were removed during a control program. A non-toxic feral cat bait would be placed at each bait station until it was removed by a cat. After the bait was removed, toxic baits would be placed at this bait station and the adjacent one on

either side. Toxic baits not consumed would be taken off at dawn to reduce any likelihood of removal by the human population and then replaced again in the early evening.

A second study was undertaken over the period 9 October – 4 November 2004 to facilitate refinement and validation of the bait-delivery technique developed in the pilot study. The main focus of this program was to assess the efficacy of the proposed baiting technique across the feral cat population (i.e. was there any bias in bait consumption with respect to sex and age classes). Target specificity of the bait-delivery mechanism was also examined. We report the results of this second study here.

Methods

Study area

Christmas Island, an area of 135 km², is located in the Indian Ocean at 10°25'S and 105°40'E, ~360 km south of Java and 900 km north-east of the Cocos (Keeling) Islands. The oceanic island is composed primarily of Tertiary limestone overlying volcanic andesite and basalt (Tidemann *et al.* 1994; Environment Australia 2002). The island rises steeply from the surrounding ocean and consists of a series of fringing limestone terraces separated by rugged limestone cliffs and scree slopes, rising to a central plateau at ~200 m and extending to 360 m

above sea level. The Christmas Island National Park was declared in 1980 and, including extensions in 1986 and 1989, now comprises over 60% of the island (Environment Australia 2002). In 2000 the park became a Commonwealth Reserve under the *Environmental Protection and Biodiversity Conservation Act 1999*. Christmas Island has an equatorial climate with a distinct wet (December–April) and dry season. The mean annual rainfall is 2154 mm, with most falling in February/March and least falling in August–October. Temperature varies little from month to month. The mean daily maximum is 28°C in March/April and the mean daily minimum is 22°C in August/September. Humidity also varies little between months and usually ranges from 80 to 90%. The island is mostly covered in tropical rainforest, described in detail elsewhere (Environment Australia 2002).

Bait and bait-delivery technique

The feral cat baits used were manufactured at the Department of Environment and Conservation Bait Factory, Western Australia. This bait is similar to a chipolata sausage in appearance, ~20 g wet-weight, dried to 15 g, blanched (that is, placed in boiling water for 1 min) and then frozen. The bait is composed of 70% kangaroo meat mince, 20% chicken fat and 10% digest and flavour enhancers (Patent No. AU 781829). Toxic baits are dosed at 4.5 mg of sodium monofluoroacetate (compound 1080) per bait. Baits are generally thawed and placed in direct sunlight before laying. This process, termed 'sweating', causes the oils and lipid-soluble digest material to exude from the surface of the bait. All baits are sprayed during the sweating process with an ant-deterrent compound (Coopex[®]) at a concentration of 12.5 g L⁻¹ as per the manufacturer's instructions. This process is aimed at preventing bait degradation by ant attack and deterring bait acceptance by the physical presence of ants on and around the bait medium.

Each bait station comprised a non-toxic cat bait suspended from a gantry, ~30–40 cm above the ground using 6–8-lb fishing line. The gantry design consisted of a vertical steel rod (12 mm diameter, 1000 mm in length) with a sharpened point at the ground end. A 30-mm steel washer (2.5 × 30 mm, internal hole 13.5 mm) was spot-welded 90 mm from the opposite end. The gantry arm was a 5-mm diameter rod, 480 mm long and spot-welded to a 20-mm pipe (20-mm diameter × 2.5-mm wall black pipe × 50 mm), 10 mm from the end at an angle of ~120° from the long end of the pipe. The opposing end of the arm had a 30-mm steel washer spot-welded vertically on its outer edge for tying the suspended bait. The gantry was installed at each bait station by hammering the vertical rod into ground until it was firmly held. A plastic plate (230-mm-diameter plastic plate or bucket lid with a 13-mm hole in the centre) was then placed on top of the rod, seating it firmly on top of the washer. The gantry arm pipe was then seated on top of the plate so that it rested ~120° to the vertical. The arm was pivoted to the desired location and locked in place by hammering a 20-mm clout at the top of the vertical rod, between the rod and the inside of the pipe. The gantry design is shown in Fig. 1.

To permit bait stations to be accessed easily and in a timely manner by the researchers, and to facilitate adequate trap-sampling of the feral cat population, placement of bait stations was restricted to the main roads. Bait stations were placed at

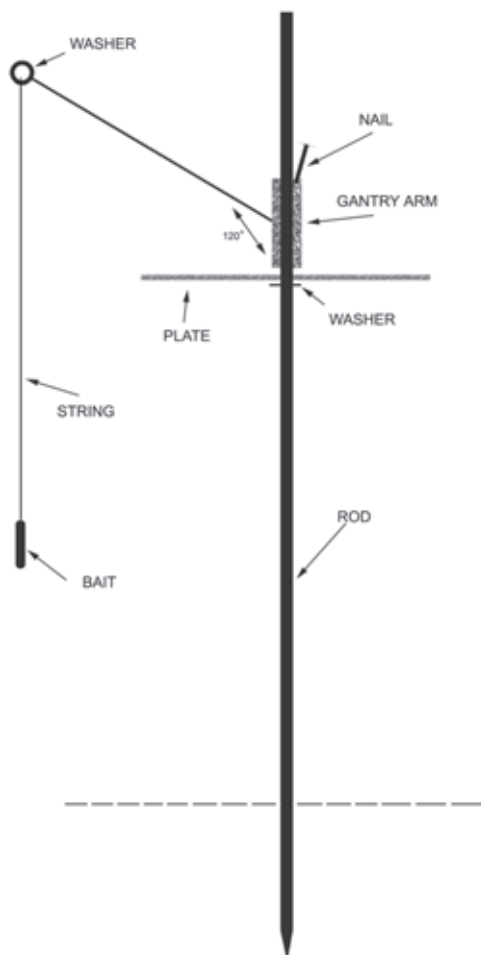


Fig. 1. Design of bait-suspension gantry.

Table 1. Road location of the bait stations

Location	Distance (km)	Bait station nos
Murray Road to North West Road	5.4	1–54
North West Road to Dales	7.1	55–126
East–West baseline to Murray Road	2.9	127–156
Corner of Murray Road and East–West baseline to North–South baseline	4.4	157–201
North–South baseline to South Point Temple Road	6.2	202–264
North–South baseline to Airport	6.7	265–332

100-m intervals along the edge of the road and their locations were recorded using a Garmin GPS 12XL. The road did not have a sandy substrate that would permit identification of individual species tracks so a ‘sand pad’, using crushed rock phosphate dust, 40 × 40 cm, was located beneath each bait and cleared daily of track activity. The survey route was 32.7 km long and provided a total of 332 bait stations. The main roads used are listed in Table 1 and their location shown in Fig. 2.

Each bait station was examined daily, over a 20-day period, to see whether the bait had been taken and whether there was evidence of cat activity on the sand pad. Bait removal by non-target species could also be identified by tracks on sand pads, and this was recorded. When baits had been removed by cats from the same bait stations on at least two consecutive days that bait station was designated for trap placement (see below). Baits were replaced following removal and all bait stations were rebaited with fresh baits at 5-day intervals. During the course of bait station placement and monitoring, cats were occasionally sighted and their location and coat colour were recorded.

To be able to assess the efficacy of this baiting technique across the feral cat population, it was necessary to collect and identify individual cats when they interacted with specific bait stations. To be able to identify individual cats, a trapping technique was employed. The methodology adopted in this program

used non-toxic baits as the lure and leg-hold traps as the collection technique. The capture of animals at individual bait stations also provided a technique to measure cat density and distribution.

The trap system and trapping program

The trapping technique used to capture feral cats utilised Victor ‘Soft Catch’ traps[®] No. 3 (Woodstream Corp., Lititz, PA). This trapping and lure system has been used successfully, both on Cocos (Algar *et al.* 2004) and Christmas (Algar and Brazell, unpubl. data) Islands. Each trap site consisted of four traps, arranged in two pairs of two, the centre of which was directly beneath the suspended bait. The trap bed was formed so that, when lightly covered with soil, the traps were level with the surrounding ground surface. A soft foam pad of dimensions 12 × 8 × 2 cm was placed below the pressure plate to prevent soil from falling into the trap bed and compacting under the plate. The traps were then lightly covered with rock phosphate dust. It was considered unlikely that the traps would pose a threat to non-target native species as robber crabs were the only such species likely to come into contact with them when bait stations were used, but have been reported unlikely to set off the traps (van der Lee 1997). The limited number of traps available and logistic constraints precluded all the bait stations with cat activity being

**Fig. 2.** Main road locations on Christmas Island.

trapped on any given day. As such, the trapping program focussed on key activity areas. All traps were routinely checked at first light each day.

Necropsies and analyses

Trapped cats were released from the leg-hold traps into cages and transported back to the Parks Australia North compound, where they were humanely destroyed using a 0.22 calibre rifle. All animals captured were sexed, weighed and the pregnancy status of females was determined by examining the uterine tissue for embryos or placental scarring from the previous litter. A broad estimation of female age (as either kitten, juvenile or adult) was recorded according to a combination of pregnancy status and weight as a proxy for age. For males, weight alone was used as a proxy for age. The smallest weight recorded for a female that had recently given birth, at a time when sexually mature females had bred, was 2.0 kg and this was used as the minimum adult weight for female cats. Smaller females weighed 1.3–1.5 kg and they were recorded as juveniles. The smallest weight recorded for a male was 2.0 kg; this animal was arbitrarily assigned as a juvenile as all other males were at least 0.8 kg heavier, these animals were categorised as adults.

Results

Bait station response

Cat activity was recorded at 113 of the 332 bait stations across the 20-day monitoring period. Of the 113 stations with activity, 78 stations were visited on more than one night and 35 stations were visited only on the one night. It was not possible to determine how many stations an individual cat visited on a given day. There were several instances where several stations were visited until removal of a single cat, after which time those visits ceased, suggesting that some individuals may visit several bait stations. On the other hand, several animals were captured at the same bait station on occasion, indicating that visits to certain bait stations were made by several cats. As bait station activity could not be ascribed to individuals, the minimum number of cats present over the survey route could not be determined. Although the sand pad method could not detect multiple visits to bait stations on the same night, this event appears unlikely as the bait would typically be removed by the first cat in the absence of a trap. Thus, the total number of bait stations visited was considered to indicate the maximum number of individuals present on the survey route. The number of bait stations (maximum number of cats) where cat activity was recorded per day over the monitoring period is presented in Fig. 3.

Fig. 3 indicates that as trapping commences, from Day 3 on, the maximum number of cats along the survey route starts to decline. This decline in cats present is gradual and stepwise and probably constrained by the factors of trap availability and logistics mentioned earlier. It is suggested that the slope of this curve would be much steeper if the trapping program had not been limited.

Bait delivery technique and sampled cat population

The trapping program involved setting trap sites at 37 bait stations for a total of 108 trap-site-nights (number of trap sites \times number of nights in place). In total, 26 cats were captured along

the survey route during this exercise. The male-to-female sex ratio (14 males and 12 females) of these animals was 1.2, which did not differ significantly from unity ($\chi^2 = 0.15$, d.f. = 1, $P > 0.05$). The age structure of the sampled population comprised 21 adults (13 males and 8 females) and five juvenile animals (1 male and 4 females). No kittens were collected.

Cat abundance and distribution

Twenty-four opportunistic sightings of cats were recorded (on the basis of coat colour and location). These comprised 20 inferred individual animals, four of which were sighted twice, nine of which were trapped and one was found dead (road-kill).

Measurement of cat abundance and distribution was based on bait station activity, capture and records of cats sighted. Combined data from these three sources suggested that 45 cats (1.34 cats per linear kilometre) were present along the survey route. Activity at the bait stations suggested that cat activity along the roads tended to be confined to intervals of 1 km or less and these segments appeared to be discrete for individuals or groups at this time. Thus, data on the distribution of the cat population are presented as the number of cats present for the individual 1-km segments along the continuous survey route (Fig. 4) (refer to Table 1 and Fig. 2 for the location of these 1-km segments). Although cats were distributed across most of the survey route, abundance varied, with certain areas devoid of cat activity and other sites having several cats present.

Target specificity of the bait-delivery mechanism

Visits to bait stations by non-target species were not recorded unless the bait was removed; however, robber crab activity was observed daily at most bait station sand pads but only a small proportion of baits were taken by these animals. At the 332 bait stations, daily bait removal by robber crabs was $\sim 1\%$ (3.5 ± 0.5 stations (mean \pm s.e.), range 0–7), and by rats even less (0.3 ± 0.1 stations (mean \pm s.e.), range 0–2). Bait removal by non-targets generally occurred repeatedly at the same bait stations, which were those with overhanging vegetation that allowed both robber crabs and rats to climb onto the plate and gather the bait. Removal of overhanging vegetation prevented

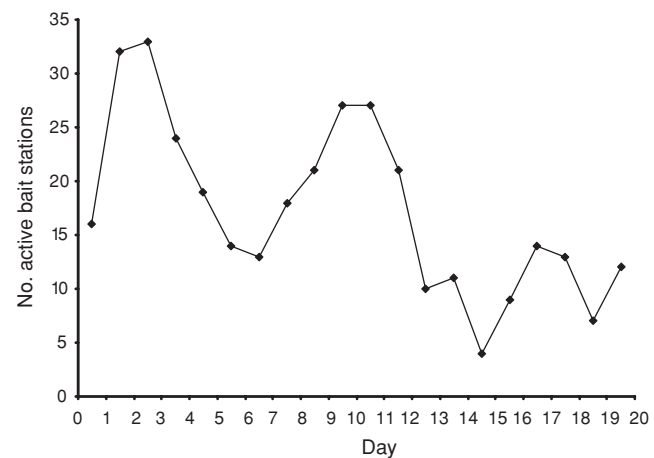


Fig. 3. Number of bait stations where cat activity was recorded per day over the monitoring period.

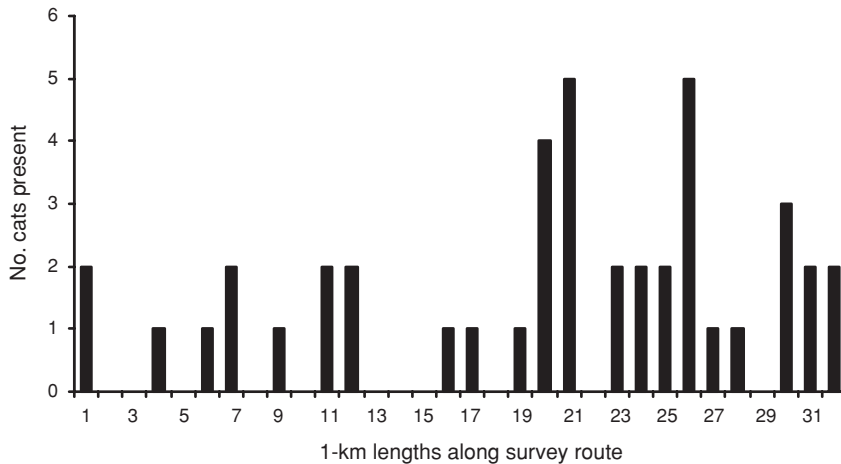


Fig. 4. Distribution of the cat population along the survey route.

any further access by non-targets. Certain plates had perforations, which also enabled crabs to gain purchase and climb over the lip of the plate and onto its surface.

Discussion

The main focus of the research program was to assess the efficacy of the bait-delivery technique to be used in the feral cat control campaign. Analysis of the sampled feral cat population indicated that the bait-delivery methodology was equally effective for both adult male and female animals, and that juvenile animals were also able to access baits. As the trap placement did not commence until after a minimum of two days' consecutive bait take, it can be assumed that, in most cases, the trapped individual had previously consumed a suspended bait. However, several cats were captured at the same bait station and therefore may have been captured on their first visit. At the time of the program, most adult females were either in the later stages of pregnancy or had recently given birth (lactating). This is the most likely reason why no kittens were present in the trapped population. It is also probable that small kittens would not be able to access the suspended baits and therefore the timing of a baiting program is important.

The use of toxic baits (instead of trapping, with its associated limitations) to remove cats during the proposed control program would result in a more rapid reduction of the cat population. One of the problems faced during this current exercise was the temporary disappearance of certain individuals before trap placement following repeated earlier and later bait station activity. This temporal change in activity at certain bait stations may have been due to the general pattern of home-range usage or, in the case of females, because they were either in the later stages of pregnancy or had recently given birth. The more readily deployed toxic baits used simultaneously across the feral cat population would overcome the problems associated with temporal and logistic constraints.

Feral cats were abundant along the survey route at a density of 1.34 cats per linear kilometre. A spotlight survey conducted along the same survey route during the pilot study in 2003 (Algar and Brazell, unpubl. data) suggested a much lower density of 0.15 ± 0.03 cats km^{-1} (mean \pm s.e.). However, spotlight surveys can only provide a somewhat limited snapshot of animal numbers at a single point in time. Reliance on spotlight

data, particularly when surveys are conducted through areas of dense vegetation, can often lead to incorrect indices of abundance. The density of cats on the island has previously been reported at 0.3 cats km^{-1} from combined spotlighting and shooting data (Tidemann 1989) and 0.19 cats km^{-1} from spotlighting data (van der Lee 1997). The cat densities recorded in these studies, despite being of a much longer duration, were lower than that determined during the current program. Differences in methodologies prevent any direct comparison of these abundance estimates and also determination of whether cat density has changed over time.

The pattern of distribution of cats along the survey route indicates that, although cats were present along most of its length, abundance varied, with certain areas devoid of cat activity and other sites having several cats present. Distribution and abundance of cats will vary with habitat preference and resource availability and is unlikely to be uniform across the landscape. This further supports the proposed strategic deployment of toxic baits in areas where cat activity is observed rather than across the entire island during the control program.

This study demonstrated the target specificity of the bait-delivery technique, with only ~1% of baits being removed daily by non-target species. Removal of overhanging vegetation and use of a smooth plate with no perforations in the bait station design is likely to eliminate any bait removal by non-target species, but this can be monitored. Preventing access to baits by non-target species, while maintaining their availability and attractiveness to the feral cat population, will enable successful implementation of a highly effective baiting strategy for the control of feral cats on Christmas Island.

The use of this bait-suspension device provides a relatively simple means to control feral cats where non-target species would otherwise have had access to baits with on-track baiting. The technique may have potential application on other islands where non-target species are threatened by baiting programs or at specific sites on the mainland where aerial or on-track deployment of feral cat baits may pose an unacceptable risk to non-target species.

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