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Multiple cameras required to reliably detect feral cats in northern Australian tropical savanna: an evaluation of sampling design when using camera traps

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Running title: Detecting cats using camera traps in the Top End

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Abstract

Context. Feral cats are a major cause of mammal declines and extinctions in Australia. However, cats are elusive and obtaining reliable ecological data is challenging. Whilst camera traps are increasingly being used to study feral cats, their successful use in northern Australia has been limited to date.

Aims. We evaluated the efficacy of camera trap sampling designs for detecting cats in the tropical savanna of northern Australia. We aimed to develop a camera trapping method that would yield detection probabilities adequate for precise occupancy estimates.

Methods. Firstly, we assessed the influence of two micro-habitat placement and three lure types on camera trap detection rates of feral cats. Secondly, using multiple camera traps at each site, we examined the relationship between sampling effort and detection probability using a multi-method occupancy model.

Key Results. We found no significant difference in detection rates of feral cats using a variety of lures and micro-habitat placement. The mean probability of detecting a cat on one camera during one week of sampling was very low ($p = 0.15$) and had high uncertainty. However, the probability of detecting a cat on at least one of five cameras deployed concurrently on a site was 48% higher ($p = 0.22$) and greater precision.

Conclusions. The sampling effort required to achieve detection rates adequate to infer occupancy of feral cats by camera trap is considerably higher in northern Australia than has been observed elsewhere in Australia. Adequate detection of feral cats in the tropical savanna of northern Australia will necessitate inclusion of more camera traps and longer survey duration.

Implications. Sampling designs using camera traps need to be rigorously trialled and assessed to optimise detection of the target species for different Australian biomes. A standard approach is suggested for detecting feral cats in northern Australian savannas.

Additional Keywords: sampling effort, detection probability, camera trap, feral cat, *Felis catus*, northern Australia

Short summary: We provide an evaluation of sampling designs using camera traps to detect feral cats in northern Australia. Neither lure type nor micro-habitat influenced detections. Our modelled relationship between effort and detection probability can be used to optimise sample design.

Introduction

Predation by feral cats (*Felis catus*) has been identified as one of the greatest threats to Australia's terrestrial mammal fauna (Woinarski, Burbidge *et al.* 2014). In northern Australia, more than 20 species of small- to medium-sized mammals have suffered severe declines during the last two decades (Fitzsimons, Legge *et al.* 2010) and predation by feral cats has been implicated as a factor responsible for these declines (Woinarski, Burbidge *et al.* 2015). However, evaluating the role of cat predation relative to other threatening processes in northern Australia, such as inappropriate fire regimes, introduced herbivores and pigs, and disease (see Woinarski, Legge *et al.* 2011) has been hampered by inadequate empirical data.

Feral cats are elusive (Edwards, de Preu *et al.* 2000) and difficult to sample with conventional trapping methods. Sampling techniques commonly used for surveying or monitoring carnivores (*e.g.* spotlighting, scat counts and sand-plot monitoring) have been found by several researchers to be ineffective in detecting feral cats (Edwards, de Preu *et al.* 2000; Mahon, Bates *et al.* 1998; Read and Eldridge 2010). The absence of effective sampling techniques for feral cats has impeded researchers from gaining an adequate understanding of their distribution and abundance, or monitoring populations for management purposes.

Camera traps provide a cost-effective, non-invasive means of detecting species that are rare or otherwise difficult to sample systematically by conventional methods, due to low detection probabilities, high personnel costs or other logistical challenges of operating intensive field sampling programs in remote areas (Foresman and Pearson 1998; Long 2008). Advances in automated remote camera technology have seen a rapid expansion of their use in wildlife research worldwide (Meek, Fleming *et al.* 2014).

Camera traps have been used successfully to study carnivore populations throughout the world (Long 2008). In Australia, camera traps are being increasingly used for research and evaluation of management programs of feral cats (*e.g*. Bengsen, Butler *et al.* 2011; Robley, Ramsey *et al.* 2008; Wayne, Maxwell *et al.* 2013). Whilst camera traps have the potential to be a useful tool for assessing and monitoring feral cat populations, there have been few studies to evaluate deployment methods or sampling effort (Robley, Ramsey *et al.* 2008; Wayne, Maxwell *et al.* 2013). Preliminary trials of camera traps to detect feral cats in the tropical savannas of northern Australia, using similar methods as applied in southern Australia (*e.g*. Bengsen, Butler *et al.* 2011; Robley, Gormley *et al.* 2010; Robley, Ramsey *et al.* 2008; Wayne, Maxwell *et al.* 2013), have yielded extremely low detections that are inadequate for evaluating spatial and temporal patterns of occurrence or population density (Department Land Resource Management (DLRM), *unpublished data*).

Developing reliable methods to detect feral cats is essential to accurately determine their current distribution, and for monitoring the efficacy of future management. We aimed to develop a camera trapping method that would yield adequate detection probabilities ($p > 0.3$; MacKenzie, Nichols *et al.* 2002) to allow precise occupancy estimates and evaluation of spatial and temporal patterns of feral cat occurrence in the tropical savanna ecosystem of northern Australia. Furthermore, we wanted to develop a methodology that could be incorporated into standard biodiversity inventory and monitoring procedures (*e.g.* Woinarski 2010). In this study we assessed the influence of different lures and camera placements on detection rates, and examined the influence of sampling effort on detection probabilities.

Materials and methods

Field trials

This study was undertaken between October 2012 and January 2014 in six areas of the Top End (north of 18˚S) of the Northern Territory (Figure 1), across a range of land tenures including protected areas, leases recently used for pastoralism and peri-urban areas. Separate trials were conducted to examine: (i) the influence of different lure types and deployment habitats on detection rates; and (ii) the influence of camera trapping sampling intensity on cat detection probabilities.

<Figure 1. Map of area>

Trial 1 – Testing different lure types

We consulted the literature (Bengsen, Butler et al. 2011; Moseby, Stott et al. 2009; Robley, Gormley et al. 2010) and various practitioners (Dave Algar, Department of Environment and Conservation, WA; Michael Johnston and Jenny Nelson, Arthur Rylah Institute; Hugh McGregor, Australian Wildlife Conservancy (AWC); Katherine Moseby, Arid Recovery) to determine lure types currently being used in Australia for attracting feral cats. We subsequently identified three common lures for trial: a food lure (fresh chicken coated with fish oil), an auditory lure (Feline Audio Phonic (FAP): Westcare Industries, Nedlands, Western Australia), and a scent lure (Cat-astrophic, a proprietary product developed by Outfoxed Pest Control). A visual attractant, consisting of a white and pink feathers and a shiny compact disk, was used in conjunction with each lure type to appeal to cat hunting instincts and increase the ability of a cat to detect the lure station (Bengsen, Butler *et al.* 2011).

One practitioner indicated higher success in detecting cats in the tropical savanna of Western Australia when cameras were placed along discrete habitat pathways, such as dry creek beds, narrow gullies, or edges of dense vegetation (Hugh McGregor, AWC, pers. obs.). Accordingly we also trialled two classes of habitats for camera placement: (i) along discrete pathways, comprising open paths through or adjacent to dense vegetation, dry creek beds or gullies (‘Closed’); and (ii) open woodland areas with no discernable pathways (‘Open’). Cameras were deployed at least 50 m away from roads as we wished to develop sampling methods that would be effective in untracked areas, and in order to minimise potential interference from dingoes (*Canis dingo*) and stray dogs (*Canis lupus domesticus*).

A factorial design was used to test the three lure types and two types of habitat in four study areas (Table 1). In October 2012 we deployed infra-red cameras (Reconyx HC600 or PC800; Holmen, WI, USA) at each of 84 stations for 20 consecutive nights. Stations were placed a minimum of 2 km apart. At each station, two cameras were deployed next to each other (either on the same tree or adjacent trees) but facing different directions, each with their own lure. Cameras were secured to a tree, at a height of 100 cm and 2 m from the lure. Lures were attached to a fibreglass pole or metal fence dropper at 1m above ground level. The auditory lure was attached directly with wire. The food and scent lures were placed inside a wire cage (8 x 13 x 19 cm) which was secured to the post using metal clasps. For the scent lure, two cotton-wool balls were soaked in Cat-astrophic prior to being placed inside the wire cage. Visual attractants, which moved in the wind, were attached to an adjacent tree with fishing line and out of the focal area of the camera. Camera orientation was between SW and SE to avoid false detections from the sun and angled so the focal point of the camera was facing the base of the lure station. Vegetation was cleared from in front of the camera to provide a detection zone that was relatively clear of vegetation in order to maximise animal detections and to minimise false triggers. Each camera was programmed to take three successive photos upon trigger with a one second interval between triggers. Cameras were run continuously to record diurnal and nocturnal activity and each image was date- and time-stamped.

<Table 1. trial 1 treatment types >

Trial 2 – Assessing sampling effort

On the basis of results from the lure trial, and preliminary data from a small mammal camera-trap trial undertaken in Arnhem Land (DLRM, *unpublished data*), we opted to increase the number of camera-traps deployed per site to five. The aim was to improve detection of cats, and a range of other species, to complement biodiversity inventory and monitoring methods currently employed by the Northern Territory Government.

Cameras were deployed at 60 sites between June 2013 and Jan 2014 for 1 - 11 weeks at a survey location (Table 2). Variability in camera deployment time was due to camera malfunction, destruction due to bushfires, and logistic constraints in camera recovery at some sites. Sites were a minimum of 1 km apart. At each site, five cameras were deployed in a diamond configuration with a single camera in the centre and four cameras placed between 30 -100 m from the centre point (Figure 2). Within any site, individual cameras were deployed in different microhabitats in order to sample habitat variability across the site. We deployed infra-red and white-light cameras (Reconyx HC550, HC600 or PC850; Holmen, WI, USA), ensuring a mixture of all models at each site. Each camera was deployed with a bait station containing standard small mammal bait mix consisting of peanut butter, oats and honey; we used standard mammal bait in order to maximise detection of native species, as these deployments were undertaken as part of wider biodiversity studies. Bait stations were constructed using an 80 mm length of PVC pipe with ventilated end caps to allow the scent to escape. The bait station was placed 30 cm above the ground and secured to a sturdy metal stake. The base of the metal stake was sprayed with Coopex Residual Insecticide© (Bayer AG, Pymble, NSW, Australia) to repel ants. Cameras were secured to a tree or other solid structure, such as rock ledge, at a height ranging from 50 - 70 cm and at 2 - 3 m from the bait station, depending on the habitat and terrain. Camera orientation and programming was the same as for Trial 1.

<Table 2. trial 2 camera-traps>

<Figure 2. 5camera-trap diagram>

Statistical analysis

Trial 1 – Testing different lure types

For the lure trial, data were analysed with a logistic regression model with binomial errors, implemented in R version 3.1.0 (R Core Team 2014). The response variable was detection / non-detection of a cat at a station over the deployment period, and explanatory variables included deployment habitat and lure type. We fitted a model with an interaction term between habitat and lure and a simpler model with only main effects for habitat and lure. We compared the two models using ANOVA.

Trial 2 – Assessing sampling effort

Cats move throughout their entire home range continuously (Moseby, Stott et al. 2009). Therefore, it could take several weeks for a cat to encounter a fixed camera trap, meaning it could be unavailable to be detected for part or all of a survey period. This issue of unavailability violates the closure assumption of standard occupancy modelling and may result in biased estimates of occupancy (MacKenzie, Nichols *et al.* 2006). Therefore, we used a multi-scale occupancy model that simultaneously estimates site occupancy, a temporal availability parameter (θ) and detection probability as described by Nichols and Bailey et al. (2008). Estimates of θ can reflect influences such as the species range size, movement distances, local densities, and seasonal activity patterns (Nichols, Bailey *et al.* 2008). Multi-scale occupancy models permit modelling of presence-absence data at two spatial scales, account for non-independence of detections between spatial scales, and allow for situations when a species is temporarily unavailable for detection due to movement (Mordecai, Mattsson *et al.* 2011; Nichols, Bailey *et al.* 2008). This model also allows gaps in the encounter history where no data were collected. For example, if a camera failed to operate during a given sampling occasion, then the entry corresponding to the camera would be missing for that occasion in the encounter history.

Data from ten consecutive weeks of surveys at each location were used in the analysis. An encounter history was derived from our camera trapping data for cats by collapsing detections across seven trap-nights (*i.e.* one week) from a single camera into a single value (0 = no detection, 1 = detection). For each of S sampling units (sites) there were up to $K = 10$ sampling occasions (weeks), and $L = 5$ devices (camera traps). We ran a multi-method model in PRESENCE Version 6.2 (Hines 2006) to model the detection data to estimate the following parameters: p = Pr(detection by a single camera trap during one sampling occasion (1 week) | site is occupied); θ = Pr(species is available to be detected during a sampling occasion | site is occupied); ψ = Pr(sample unit is occupied/used by the species). Although we recognise that detection probabilities are likely to vary both spatially and temporally, we did not model any covariates as our aim was to obtain an average detection probability across the survey locations to guide future sampling efforts for cats across the Top End. Three models were fitted to the data: (1) all parameters were held constant across all sites and cameras [$\psi(.)\theta(.)p(.)$]; (2) detection probability may vary among cameras within a site[$\psi(.)\theta(.)p(\text{camera})$]; and (3) where θ was time-dependent [$\psi(.)\theta(t)p(.)$]. Akaike Information Criteria (AIC) were used for model selection (Burnham and Anderson 2002), and a goodness-of-fit test was performed on the most parameterised model to assess fit of the model to the data (MacKenzie and Bailey 2004).

To assess the influence of the number of cameras used per site on the detection probability of cats we randomly sub-sampled the data to obtain 15 datasets using two to four cameras (5 datasets for each set of cameras). Encounter histories were derived for each sub-sample by collapsing detections from multiple cameras at each site across seven trap-nights into a single detection / non-detection. A single dataset using all five cameras per site was also generated. Single-season occupancy models were run on each dataset to estimate the probability of detecting a cat on at least one camera during a single sampling occasion given the site is occupied (MacKenzie, Nichols *et al.* 2002). Single-season occupancy models combine local-presence (availability) within the detection estimate (Nichols, Bailey *et al.* 2008).

Cumulative detection curves using one to five cameras at a site were generated using mean estimated detection probabilities and 95% confidence intervals obtained from the occupancy models. Cumulative detection is the probability of detecting a cat in at least one of K surveys carried out at an occupied site ($p_L^* = 1 - (1 - p_L)^K$) (MacKenzie and Royle 2005).

Results

Testing different lure types

Some minor camera failures were experienced (8 of 168 cameras), resulting in data from 160 cameras from 82 stations being included in analyses. A total of 18 detections of cats were recorded across 160 cameras and 3200 trap-nights. Cats were detected at 17% of the camera stations (14 of 82). One station detected cats twice over the 20 nights; 13 stations recorded only single detections. Only two stations recorded near-simultaneous detections of a cat on paired cameras (images from both cameras had the same time-stamp). Significantly more cats were detected when data from paired cameras were pooled for each station, than if data from one camera per station was randomly excluded (Sign test: $P < 0.001$). We found no evidence for inclusion of an interaction term in our models (Deviance = 1.03, d.f = 2, $P = 0.59$). There was no significant difference in detections between lure types ($P > 0.38$) or between camera deployment habitat ($P = 0.87$) (Figure 3). Cats showed little behavioural interest in any of the lure types, with no cats photographed sniffing, scent marking or attempting to obtain the lure.

<Figure 3. trial 1 graph>

Assessing sampling effort

We failed to obtain data from ten of 300 cameras due to camera and operator fault. From the ten sampling occasions we recorded 57 cat detections on 39 camera traps at 24 sites (naïve occupancy = 0.40). Cats were detected in all four study areas. The model varying detection probability among cameras within a site $\psi(.)\theta(.)p(\text{camera})$ was the most parsimonious multi-method model with 95% of the AIC weighting. There was considerably less support for the constant model $\psi(.)\theta(.)p(.)$ (ΔAIC = 6), or the time-dependent $\psi(.)\theta(t)p(.)$ model (ΔAIC = 16). The mean estimated probability of detecting a cat on a single camera trap during one sampling occasion (seven days) was low ($p^{1}_{mean} = 0.15$, Range: 0.05 - 0.23) and there was evidence of variation in detection probabilities between cameras within sites (Table 3). Cats were available to be detected by the cluster of cameras at an occupied site less than 50% of the time ($\theta = 0.44$, SE(θ) = 0.11) consistent with our expectation that there would be high local movement. The occupancy estimate adjusted for incomplete detection and availability (ψ = 0.52, SE(ψ) = 0.09) was 30% greater than the naïve occupancy.

Mean estimated probabilities of detecting a cat on at least one camera during a single sampling occasion given the site was occupied, from the single-season occupancy models, produced similar results using two cameras ($p^{2} = 0.14$) and three cameras ($p^{3} = 0.16$), and a 33% increase using four cameras ($p^{4} = 0.20$). The probability of detecting a cat on at least one of five cameras deployed on a site was 48% higher ($p^{5} = 0.22$). The uncertainty in the estimated detection parameter when using varying numbers of cameras concurrently on a site increased as the number of cameras decreased and significantly influenced the precision of cumulative detection probabilities (Fig. 4).

<Table 3. Multi-method parameter estimates>

<Figure 4. Cumulative detection curves>

Discussion

We found no evidence of an effect of lure type on detection rate of cats across four study areas in northern Australia. Further, our observations of cats on cameras suggest that most of our detections were not derived from attraction to lures *per se*. Wayne, Maxwell *et al.* (2013) also found lure type did not significantly affect detection rates in south-western Australia, and Read, Bengsen *et al.* (2015) found audio and olfactory lures elicited behavioural interest from cats but did not increase visitation rates. However, some studies in temperate climates in southern Australia have successfully used fresh chicken and tinned fish as lures to attract feral cats to camera traps with relatively high detection rates (mean $p = 0.5$ per 3 day sampling occassion, Bengsen, Butler *et al.* 2011; daily $p = 0.05$, Robley, Gormley *et al.* 2010). Fresh chicken and fish desiccate very quickly in tropical environments and rapidly attract ants, which likely reduced their usefulness for attracting cats in our trial.

Although limited data is available, cats may occur in lower densities in savanna ecosystems of northern Australia (0.18 km^2; McGregor 2015) compared to temperate Australia (> 0.7 km^2; reviewed in Denny and Dickman 2010). The density in which a species occurs in the landscape will have an influence on detection probabilities (Royle and Nichols 2003). Our ability to detect a cat with a single camera trap was low with high variability in the estimate. However, the use of multiple cameras concurrently at a site increased the probability of detection and the precision in the estimate. Cats exhibit intra-specific variation in activity patterns and home range, but generally use a focal area for short periods of time and then foray more broadly within the area of their long-term home range (Edwards, de Preu *et al.* 2001; Moseby, Stott *et al.* 2009). Our analysis revealed that cats were present in a site during a survey (if occupied) approximately 50% of the time consistent for a mobile species which uses an area larger than the sampling unit. The temporal availability parameter (θ) is influenced by daily and seasonal activity patterns, movement distances, local densities (Nichols, Bailey *et al.* 2008). Therefore, it can be assumed that cats will be unavailable for sampling at 'occupied' sites at a fraction of visits (sampling occasions).

When detection probability for a species is low, greater survey effort is required in order to obtain unbiased occupancy estimates (MacKenzie, Nichols et al. 2002). Further, without sufficient survey effort the probability of a false absence at a site may be sufficiently large that it is difficult to identify any important factors associated with occupancy. MacKenzie, Nichols et al. (2006) state that inference about factors that influence occupancy is best when the probability of a false absence [$p^f = (1 - p)^K$] is in the range of 0.05 – 0.15. Based on our mean estimates of detection, deploying five cameras per site for 8 weeks or four cameras for 9 weeks is required to achieve a probability of a false absence < 0.15, and using fewer cameras increases deployment times to greater than 10 weeks (Table 4). However, these estimates are based on maximising cat detections using a survey design for monitoring and evaluating general biodiversity when the aim is to minimise the level of uncertainty about the occupancy status of cats across a broad landscape.

Study designs which aim to specifically target cats for management and control purposes may obtain higher detection probabilities with targeted placement of cameras. Read, Bengsen *et al.* (2015) and McGregor (2015) observed higher capture rates of cats when cameras were placed on roads. McGregor, Legge *et al.* (2014) observed that cats more often selected areas with an open grass layer and had high densities of small mammals in north-western Australia. Furthermore, the height above ground which cameras are set may also influence image capture rates of cats (Ballard, Meek *et al.* 2014), camera heights of 20 – 40 cm have been used in some studies specifically targeting cats especially for density studies (McGregor 2015; Read, Bengsen *et al.* 2015). Lastly, camera type could influence recaptures of individuals on camera; for example, behavioural avoidance of white flash cameras has been reported for tigers (Wegge, Pokheral *et al.* 2004). Although these issues are not explored in our study they should be considered in the design of studies that specifically aim to target cats.

Occupancy can be an informative state variable for biodiversity monitoring, but it is important to incorporate detectability in order to make inferences about species distributions and habitat associations (Bailey, Simons *et al.* 2004; MacKenzie, Nichols *et al.* 2006; O'Connell Jr., Talancy *et al.* 2006). In any occupancy study design there will be trade-offs between spatial and temporal replication; increasing the number of sites increases statistical power except when false-negative errors are great and then the number of sampling occasions at each site should be increased (MacKenzie and Royle 2005; Tyre, Tenhumberg *et al.* 2003). Accurate estimates of occupancy require maximising the overall probability of detecting the species of interest during each sampling occasion. As we demonstrated, the number of camera traps per site has a significant effect on the probability of detecting cats in the Top End and the confidence in this estimate.

When deciding on how many devices to deploy at a site, it is also important to consider the failure rate of the devices. The use of multiple camera traps at a site can reduce the loss of data when single devices are rendered inoperable due to environmental circumstances (*e.g.* fire), technical faults, or operator error. As high quality camera-traps are moderately expensive, there will be trade-offs between the number of cameras that can be deployed per site, the deployment time and the number of sites that can be sampled given the number of cameras available. Having clear objectives will help guide these decisions keeping in mind the relationship between detectability and occupancy, and the optimal number of sampling occasions required to maximise precision.

<Table 4 false absence>

Management implications

It is widely recognised that animals are detected imperfectly in all wildlife surveys, and this is an important aspect that must be considered in wildlife monitoring and management programs. This study demonstrates that a relatively intense survey effort is required when using camera traps to understand occupancy status of cats across a broad landscape in the savanna ecosystems of northern Australia. As one component of general biodiversity inventory and monitoring programs in the Top End of the Northern Territory, we are now obtaining data on site-occupancy by cats. The large dataset accruing from these camera trap surveys will be used to further refine our methods, and to inform our understanding of the distribution of cats in the Top End of the Northern Territory and their association with small mammal population status.

The Northern Territory Government has developed a *Standard Operating Procedure* for camera trapping to be incorporated into general biodiversity assessment by both indigenous and non-indigenous land managers, consultants and researchers working in the Top End of the Northern Territory. We conclude that single camera traps deployed at a site will be inadequate in detecting feral cats in the tropical savanna of northern Australia, and that to achieve detection rates adequate to infer occupancy will necessitate inclusion of more camera traps and longer survey duration. We recommend biodiversity managers and researchers in other regions similarly trial and assess their methods to optimise detection of the target species.

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List of Figures

Fig 1. Map displaying the locations of the study areas within the Top End of the Northern Territory.

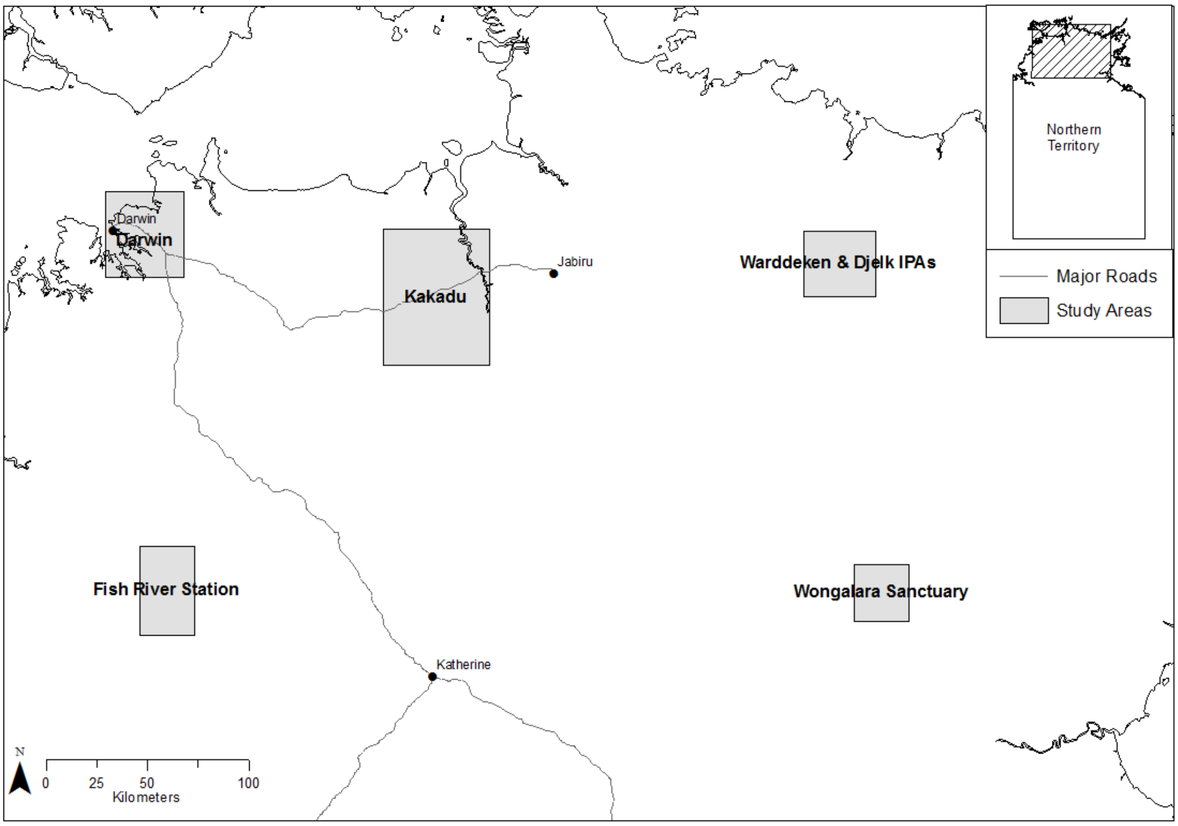


Fig 2. Diagram depicting an array of 5 camera traps deployed around a 50 x 50 m grid typically used in small mammal surveys using conventional trapping techniques.

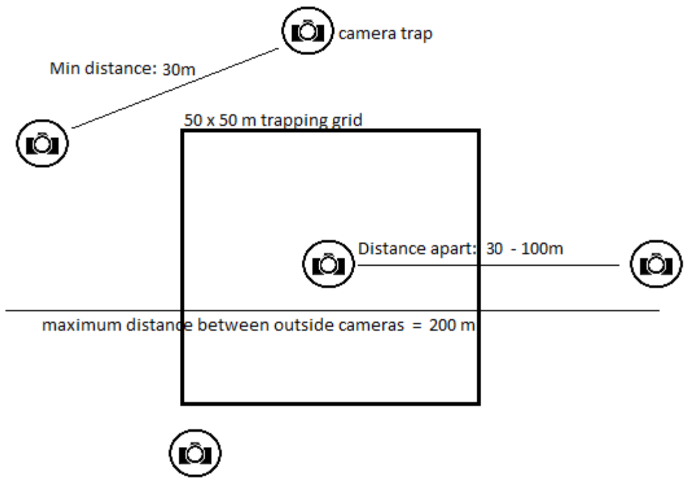


Fig 3. Proportion of stations in Trial 1 that detected cats displayed by treatment class.

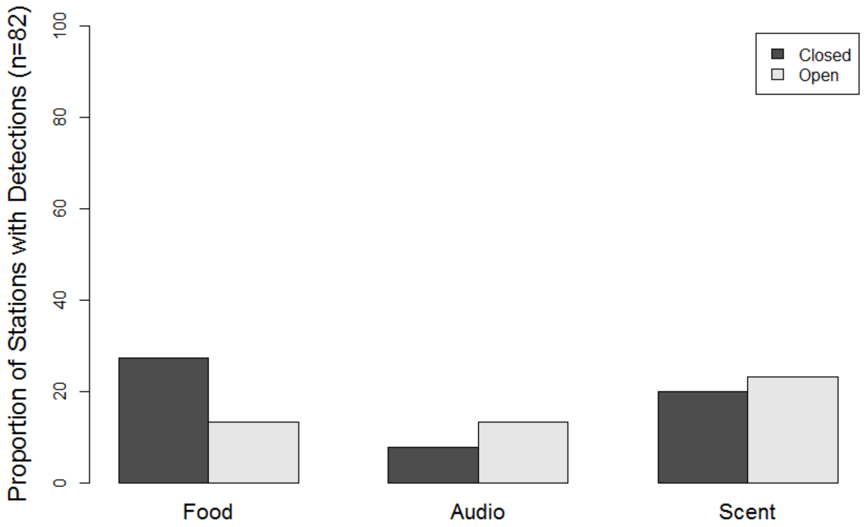
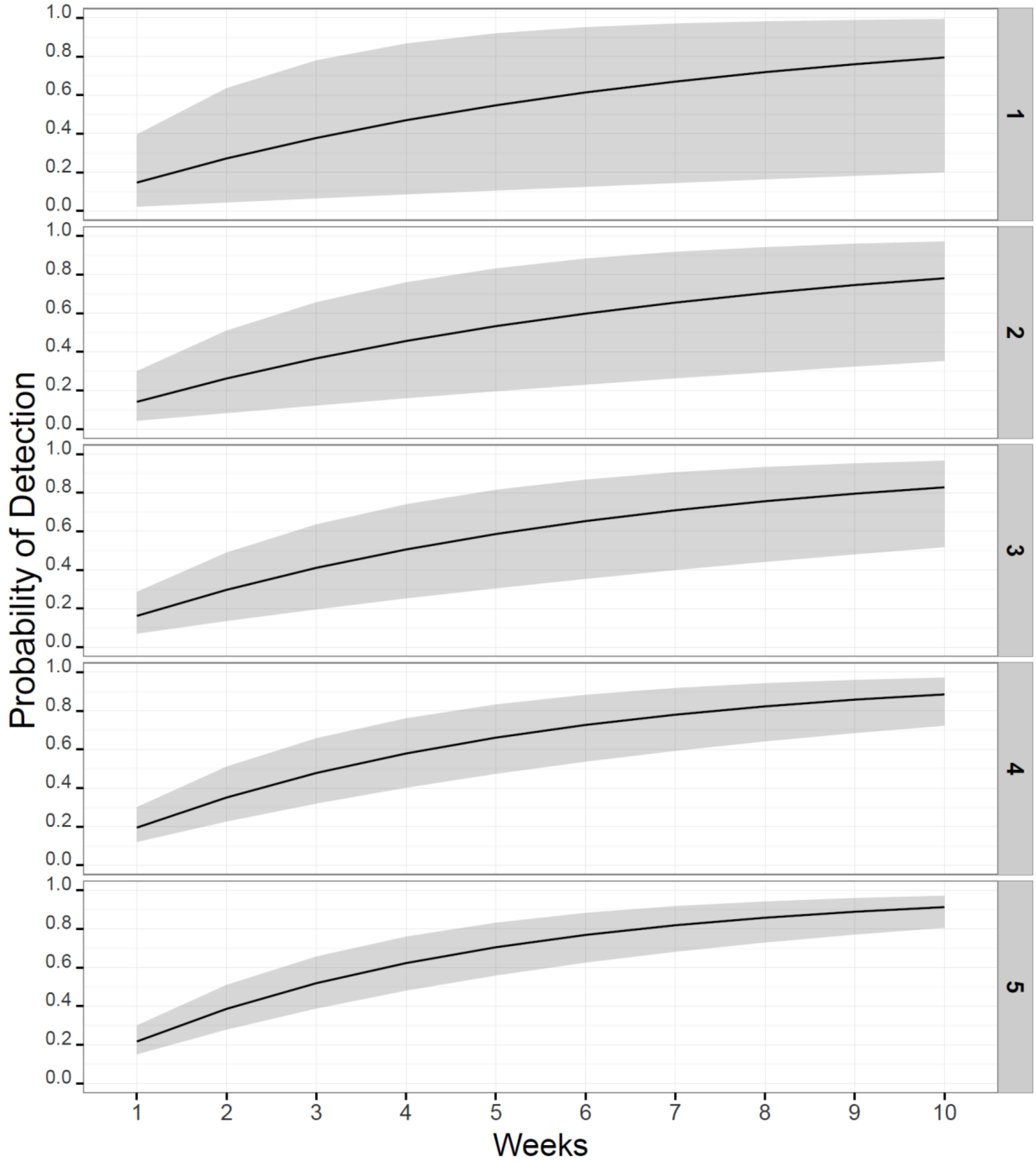


Fig 4. The probability of capturing at least one image of a cat at an occupied site using different numbers of camera traps when deployed for multiple weeks. Shaded area represents the 95% confidence interval in the probability of detection estimate.



List of Tables

Table 1. Number of camera trap stations deployed for each treatment type and study area in Trial 1.

	Kakadu		**Warddeken**		**Wongalara**		**Fish River**		**Total**
Lure Type	Open	Closed	Open	Closed	Open	Closed	Open	Closed	
Food + visual lure	4	4	4	4	4	4	2	2	28
Audio + visual lure	4	4	4	4	4	4	2	2	28
Scent + visual lure	4	4	4	4	4	4	2	2	28

Table 2. The mean number of weeks that camera traps were deployed during each survey in Trial 2, number of sites and number of functioning cameras.

Survey Area	**No. of Sites**	**No. of Cameras**	**Survey Period**
Djelk IPA	10	44	Aug 2013
Kakadu	10	50	Oct 2013
Darwin	28	139	Jan 2014
Warddeken IPA	12	57	Aug 2013
All Locations	**60**	**290**	

Table 3. Parameter estimates for the top ranked multi-method occupancy model [$\psi(.)\theta(.)p$(camera)] fit to cat detection data from 60 sites incorporating five cameras within each site.

Parameter	**Estimate**	**SE**
ψ	0.516	0.091
θ	0.442	0.111
***p*[1]**	0.151	0.049
***p*[2]**	0.052	0.028
***p*[3]**	0.094	0.037
***p*[4]**	0.231	0.071
***p*[5]**	0.206	0.065

Table 4. Probability of obtaining a false negative error in detecting cats in the Top End using varying numbers of camera traps over multiple weeks. The shading highlights the number of weeks where false absences [$p^f = (1 - p)^K$] are minimised to < 0.15.

No. of Cameras	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	0.853	0.728	0.622	0.530	0.453	0.386	0.330	0.281	0.240	0.205
2	0.859	0.738	0.634	0.544	0.468	0.402	0.345	0.296	0.255	0.219
3	0.839	0.703	0.590	0.494	0.414	0.348	0.291	0.244	0.205	0.172
4	0.805	0.649	0.522	0.421	0.339	0.273	0.220	0.177	0.143	0.115
5	0.784	0.614	0.481	0.377	0.295	0.231	0.181	0.142	0.111	0.087