Wildlife detector dogs and camera traps: a comparison of techniques for detecting feral cats

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Running head: Wildlife detector dogs vs cameras

Abstract

A major challenge in controlling overabundant wildlife is monitoring their populations, particularly as they decline to very low density. Camera traps and wildlife detector dogs are increasingly being used for this purpose. We compared the cost-effectiveness of these two approaches for detecting feral cats (*Felis catus*) on two pastoral properties in Hawke's Bay, North Island, New Zealand. One property was subject to intensive pest removal, while the other had no recent history of pest control. Camera traps and wildlife detector dogs detected cats at similar rates at both sites. The total cost of each method was also comparable; however, camera traps had a higher set-up cost and lower operating cost than wildlife detector dogs. We identify a number of advantages and disadvantages of each technique, and suggest priorities for further research.

Keywords: carnivore, cryptic pest species, *Felis catus*, invasive predator, monitoring

Introduction

Invasive predators are one of the greatest threats to global biodiversity, and their impacts in Australia and New Zealand have been catastrophic (Salo et al, 2007; Simberloff 2010). Control of invasive predators is often hindered by the difficulty of detecting them in the field; often they are cryptic, highly mobile, and occur at low density (Clayton & Cowan 2010; Marks et al. 2009; Witmer 2005). However, even very low densities of invasive predators can threaten populations of vulnerable native species (e.g. Innes et al. 2010). Camera trapping is an increasingly popular technique for monitoring cryptic carnivores (e.g. Bengsen et al. 2011a,b; Brook et al. 2012; Karanth 1995; Lyra-Jorge et al. 2008; Meek et al. 2014). Wildlife detector dogs are also highly effective at communicating the presence of carnivores and/or their scats (Brown et al. 2015; Long et al. 2007a,b; Recio et al. 2010).

Feral cats (*Felis catus*) have become widely established around the globe (Abbott et al. 2014; Campbell et al. 2011; Nogales et al. 2004), causing decline and extinction of native species, as well as detrimental impacts on humans and livestock (Glen et al. 2013a; Medina et al. 2011, 2014). To protect native prey species, cats are subject to lethal control in parts of Australia and New Zealand (Algar et al. 2007; Moseby & Hill 2011; Reardon et al. 2012). The effectiveness of control is often judged by numbers of animals removed, which provides no information on the numbers that remain (Glen et al. 2014), or by indirect measures of activity such as spoor or spotlight counts, which can suffer from low precision (Cruz et al. 2013). An affordable, accurate, and precise monitoring method would better allow managers to decide where and when additional effort is needed to control feral cats. The ability to detect feral cats at very low density is also important in eradication campaigns (e.g. Campbell et al. 2011; Ramsey et al. 2011), when every last animal must be detected and/or removed. We conducted a field trial comparing the effectiveness of camera traps and wildlife detector dogs in two areas, one of which had been subject to intensive cat control. We aimed to determine: (1) whether each method could detect cats at relatively high and low abundance; and (2) which method was more cost-effective for detecting cats.

Methods

Study sites

We monitored feral cats on two pastoral properties – Waitere and Toronui stations – in Hawke's Bay, North Island, New Zealand. Both properties are predominantly covered by introduced pasture with remnants of native vegetation. The farm landscapes include many steep gullies, which often contain thick scrub.

Waitere Station had been subject to trapping and removal of feral cats and ferrets (*Mustela furo*) for 3 weeks immediately before our trial commenced. A combination of leg-hold, cage, and kill traps were placed throughout the property, checked daily, and captured cats and ferrets were removed. The results of the predator control will be reported in detail elsewhere; however, detections of feral cats with camera traps fell by 90% following control, suggesting that most resident cats had been removed. Toronui Station had no recent predator control. We therefore classify Toronui Station as the high-density site, and Waitere as the low-density site.

Predator monitoring

Predators were monitored using 80 camera traps for three weeks in May–June 2014, giving a total of 1,680 camera trap-nights. At each site 40 camera traps (Reconyx Hyperfire PC900, Reconyx Inc., Holmen) were placed at approximately 500-m intervals, in a grid formation covering a total area of ~600 ha. A high density of cameras was required for spatially explicit capture-recapture analyses as part of a parallel study. Cameras were mounted on wooden stakes with the base of the camera 10 cm above the ground. A perforated vial containing a scent lure (fresh rabbit meat) was pegged to the ground 1.5 m in front of each camera. The lure was intended to increase the likelihood of predators encountering cameras, and to encourage predators to pause in the camera's field of view so that they could be clearly photographed (Glen et al. 2013b). Cameras were set to take three photographs each time they were triggered, with no time delay between successive triggers.

Beginning on 6 June, as the camera traps were being removed, we surveyed each site using a detector dog team comprising a handler and two cat-detector dogs, which had been working with the handler for 5 – 7 years (Conservation Dog Team, New Zealand Department of Conservation (DOC)).

In consultation with the dog handler we evaluated three possible approaches for comparing the cost-effectiveness of the camera traps and the dog team for detecting cats: (1) search within a 100-m radius of each camera trap using dogs, travelling by vehicle between search areas; (2) search along the rows of camera traps on foot, briefly circling each camera trap; (3) divide the camera trap grid into 'search cells', each containing four or more cameras, then search each cell using the dog handler's judgment to determine the optimal search pattern.

The first method was deemed unsuitable because the dogs were likely to be less effective if deployed for a series of short searches punctuated by vehicle travel; dogs cannot readily be 'switched on and off'. The second method was briefly trialled but discontinued because the dog handler judged that the fixed search pattern imposed by the grid caused likely areas of cat habitat (e.g. densely vegetated gullies) to be left unsearched. The third method was a compromise between the need to search a comparable area to that sampled by the camera traps, while operating within the practical constraints of a dog team working on foot.

Each time the dog team was deployed we used a handheld GPS to record start and finish time, path walked by the dog handler, and time and location at which the dogs detected the scent of a cat. The handler judged when cat scent had been detected based on a marked alteration in the dogs' search pattern. It was beyond the scope of this study to estimate the false-positive detection rate, therefore we assumed perfect specificity (i.e. a dog would not detect cat signs if none were present). The dog team continued to search a cell until either: (1) cat scent was detected, or (2) the handler judged that all likely cat habitat had been searched. We define this as a 'search event'. For cameras, we defined a search event as a 3-week deployment period.

For each search cell we recorded whether cats had been detected by the dogs, and/or by any of the cameras in the search cell.

Detection probabilities

We estimated the probability of detection of cats per search event using cameras and dogs (Long et al. 2007a). The detection probability of a device was conditioned on the cat population density in the area. Although the study was conducted in two areas with assumed different cat densities, both the camera and dog trials occurred under identical conditions, therefore the estimated detection probabilities were directly comparable. We used Bayesian logic and a beta-binomial model (Gelman et al. 2004) to estimate the detection probability (and associated uncertainty) per search event for each method. This approach estimates distributions of detection probabilities (posteriors), avoids single-number parameter estimates (i.e. explicitly incorporates uncertainty; Clark 2005), and allows for direct comparison of methods. The approach begins with initial distributions of detection probabilities (beta priors) for both methods that are based on previous studies or expert opinion (Gelman et al. 2004). The data collected in the study were then used to update the prior distributions using a binomial likelihood (hence beta-binomial). In this study we used uninformed priors, (i.e. any probability between 0 and 1 was equally likely), because few previous estimates were available on detection probabilities of cats using camera traps (but see Ramsey et al. 2010, 2011; Robley et al., 2008).

We conducted a power analysis to determine the number of trials required to detect a range of differences in the probability of detection using detector dogs and camera traps. A sample size was deemed sufficient with power > 0.80 $[P(reject\ H_0|H_A\ is\ true)]$. In this analysis the probability of detection is explicitly defined as the probability of detecting a single individual cat, given that it is present in the searched cell.

Cost estimates

We estimated the cost of each detection method by recording the amount of staff time required (including time taken to review camera footage), and all associated costs such as vehicles and equipment. Costs for dogs were estimated based on Long et al. (2007a) and discussions with the DOC Conservation Dog Team. We included set-up costs (e.g. purchase of cameras or dogs; training of dogs to the standard for certification from the Conservation Dog Team). The annual costs of keeping dogs (food, veterinary care, on-going training) were estimated and then converted to a daily rate, which we applied *pro rata* for the period of the survey. We compared the cost-effectiveness of camera traps and detection dogs in terms of: (1) the cost of surveying both study sites with each method, and; (2) the number of search cells in which cats were detected.

Results

The camera traps and dog team detected cats at both the high- and the low-density site; however, poor weather forced the trial to stop before the dog team had searched both sites completely. Our comparison is therefore limited to nine search cells (five on Waitere, four on Toronui), which encompassed 41 of the 80 camera traps.

Camera traps detected cats in four of the nine search cells, whereas the dog team detected cats in five cells. There were two search cells in which cats were detected by both methods (Table 1). Where cats were found, mean time to detection by the dogs was 16 minutes (range 13–25). In cells where cat scent was not detected, the dog team searched for an average of 109 minutes (range 76–140). On two occasions the dogs flushed a cat, providing visual confirmation that they had correctly identified the scent.

[Table 1 hereabouts]

Detection probabilities

The posterior mean probability of detecting cats was 0.45 per search event for cameras and 0.54 per search event for dogs. The distributions of the two posterior means overlapped extensively (Fig. 1), indicating no significant difference in detection probability between the two methods.

[Figure 1 hereabouts]

The power analysis indicated that the number of searched cells in our trial would only be sufficient to detect a very large difference (>0.6) in detection probability between the two methods (Table 2).

[Table 2 hereabouts]

Cost estimates

Because the trial was cut short when the dog team had covered approximately half the study area, we estimated the cost of surveying the entire study area by doubling the expenses incurred by the dog team in the field. We estimated the total cost to sample both study sites using wildlife detector dogs would be 85% of the cost of using camera traps (Table 3). The difference was largely due to the high set-up cost of camera traps. In terms of operating, camera traps cost 22% as much as the dog team (Table 3).

[Table 3 hereabouts]

Discussion

Our study suggests the probability of detecting cats per search event was similar using either camera traps or wildlife detector dogs. Detection probabilities would likely vary depending on the search effort involved; therefore these estimates depend on the definition of a search event. The search effort applied in this trial was intended to represent a realistic scenario for the practical use of each method.

Although both methods detected cats in a similar number of search cells, there were only two cells in which cats were detected by both dogs and cameras. This may be a result of the different spatial and temporal scales over which these methods operate; cameras sampled at a single point over 3 weeks, whereas the dog team searched more widely within each search cell, but took a more instantaneous snapshot. It is possible the dog team may have detected scats that were more than 3 weeks old, which may have been deposited by cats that were removed by the predator control. In this case, the estimated detection probability using wildlife detector dogs would be inflated relative to the estimate derived for camera traps.

The estimated cost of each method was also comparable; however, this was due to the high purchase price of the camera traps, which accounted for around 90% of their total cost. Operating costs of camera traps were very low compared with those of the dog team. Although less expensive camera traps are available, detection rates can vary substantially between different models (Glen et al. 2013b; Meek & Pittet 2012; Meek et al. 2012). We do not know whether less expensive camera traps could have achieved a comparable result. Similarly, some cost savings could accrue from using a single dog rather than a team of two, but we do not know what effect this might have on detection rates.

In order to make a fair comparison between camera traps and wildlife detector dogs, we included set-up costs for both methods. However, an alternative is to hire a dog team on a daily basis, thus avoiding set-up costs. A dog team can be hired for NZD 350 – 450 per day (K. Vincent, DOC Conservation Dog Team, pers. comm.). This would give an estimated cost of NZD 3,500 – 4,500 to survey both our study sites, which is comparable to the operating costs of camera traps (NZD 5,100; Table 3).

Camera traps deployed for longer than 3 weeks may have achieved a higher detection probability (e.g. Robley et al. 2010). While it is difficult to estimate the additional cost of deploying cameras for longer (e.g. additional analysis of footage, higher risk of camera loss / damage), it is likely these would be small compared with set-up costs.

Because our cost comparisons include set-up costs (e.g. camera purchase, dog training), they do not reflect the cost of repeated surveys using the same dogs or equipment. Subsequent surveys would incur much lower costs, especially with camera traps. Future research should compare the two methods repeatedly over a number of years. Depending on the number of times cameras are re-deployed, they may cost less than wildlife detector dogs in the long term. The useful life of camera traps will depend on their durability, as well as the conditions in which they are deployed (e.g. weather conditions, likelihood of theft).

Our estimates of detection probability using wildlife detector dogs and camera traps may help to inform the design of future studies, to estimate relative abundances of feral cats, and to assess the likelihood that eradication efforts have succeeded (e.g. Ramsey et al. 2011). To detect a significant difference in probability of detection between cameras and dogs would require a higher sample size than was achieved in this study. Therefore, although our results suggest the methods were comparable, further trials with larger sample sizes are required. Regardless, our trial illustrated a number of advantages and disadvantages associated with camera trapping and wildlife detector dogs. The effectiveness of the dog team was dependent on fair weather as the dogs' ability to detect scent is reduced by rain or strong wind (S. Aitcheson, DOC, pers. comm.). Our cost estimates are therefore based on the assumption of 10 days of fine weather; interruptions due to bad weather would increase costs. In contrast, camera traps can operate in a wide range of weather conditions, and can be deployed for long periods so that individual weather events are less likely to influence overall results.

Searching with dogs can cover an area more quickly and thoroughly than deploying camera traps at fixed positions. This may be particularly useful when rapid detection is required, e.g. a suspected incursion into a predator-free reserve. On the other hand, camera traps can operate for long periods with little or no maintenance.

Another potential advantage of wildlife detector dogs is their ability to help catch and remove animals that have survived a control programme (e.g. Ramsey et al. 2011). In contrast, camera traps are a monitoring tool only.

Camera traps may be unsuitable for use in some areas because of their vulnerability to interference by people and/or livestock. In our trial, livestock were frequently photographed by camera traps, producing many thousands of pictures and increasing the time taken to review the footage. Livestock also knocked or rubbed against cameras, sometimes leaving them inoperative. In contrast, a dog team can operate effectively in the presence of livestock. Because our trial was conducted on private property human visitation was minimal. One camera was stolen; however, the risk of theft may be much greater in areas open to the public.

Finally, camera traps can give useful data on a wide range of other species. In the course of our trial the cameras detected numerous species of mammals and birds in addition to cats (P. Garvey and M. Nichols, unpublished data). While collating the data is time-consuming, such information may often be valuable to researchers or land managers.

Future research

Our study suggests both camera traps and wildlife detector dogs may be useful for monitoring feral cats. It also draws attention to a number of questions and priorities for further research:

1) How do detection probabilities for cats compare with those for other species? Detector dogs have been used to search for various species of carnivores (Brown et al. 2011; Dematteo et al. 2009; Gompper et al. 2006; Long et al. 2007a; Reindl-Thompson et al. 2006; Smith et al. 2005; Wasser et al. 2004) and rodents (Duggan et al. 2011; Gsell et al. 2010; Shapira et al. 2011). Detection probabilities can vary widely between species (e.g. Long et al. 2007a). However, we know of no studies that compare detection probabilities of feral cats with those of other sympatric carnivores.

2) Is it more efficient for dogs to specialise in detecting one species, or to search for all carnivore scats, then use DNA to assign them to species? When combined with genetic analysis

of scats, wildlife detector dogs can provide a fast, reliable and inexpensive way to survey for cryptic species (Long et al. 2007a). In Tasmania, trained dogs detected 80% of fox (*Vulpes vulpes*) scats, even after the scats had been in the field for 63 days. After 91 days in the field, 99% of fox scats were genetically identifiable to species (Brown et al. 2011; Caley et al. 2015; but see also Marks et al. 2014).

Identifying scats to species may allow population density estimates through occupancy modelling, whereas identifying individual animals allows mark-recapture analysis (Gleeson et al. 2010; Marks et al. 2009). Identifying individuals can also tell us about their movements and behaviour. However, identifying individuals from scat DNA is more expensive and requires fresher samples than identifying species. Thus, there may be a trade-off between cost and rigour of different techniques.

3) Once the above questions have been addressed, the cost-effectiveness of detector dogs and scat DNA should be compared with other non-invasive techniques such as camera trapping.

We conclude that the choice to use camera traps or wildlife detector dogs will depend on study aims (e.g. research vs eradication), as well as site-specific factors such as weather, land-use and degree of human visitation. Although further testing is required to compare long-term cost-effectiveness, both methods can detect feral cats at relatively high and low density.

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Table 1. Detections of cats (*Felis catus*) by camera traps and wildlife detector dogs deployed for one search event (see text for definition) in each of nine search cells on Waitere Station (low predator density) and Toronui Station (high predator density), Hawke's Bay, New Zealand. (1 = cat detected; 0 = no cat detected). Figures in brackets indicate the number of days until cameras detected a cat in each search cell.

Search cell	Site	Cameras	Dogs	Dogs' search time (minutes)
1	Waitere	0	1	14
2	Waitere	1 (1)	0	98
7	Waitere	0	0	140
8	Waitere	0	1	17
9	Waitere	0	1	17
3	Toronui	0	0	112
4	Toronui	1 (2)	1	25
5	Toronui	1 (1)	1	9
6	Toronui	1 (3)	0	109
Total		4	5	541

Table 2. Power analysis showing the number of search cells required to detect a difference (pDiff) in detection probability of feral cats (*Felis catus*) using camera traps (pCamera) and wildlife detector dogs (pDog).

pCamera	pDog	pDiff	Number of search cells
0.1	0.3	0.2	61
0.1	0.4	0.3	31
0.1	0.5	0.4	20
0.1	0.6	0.5	13
0.1	0.7	0.6	10
0.1	0.8	0.7	7
0.1	0.9	0.8	6

Table 3. Itemised cost of monitoring for cats on Waitere and Toronui Stations, Hawke's Bay, New Zealand, using camera traps and wildlife detector dogs. Cost estimates for dogs are extrapolated from surveys covering approximately half of each site.

			Camera trapping		Wildlife detector dogs	
		Unit price (NZD)	Number	Cost (NZD)	Number	Cost (NZD)
Set-up	Cameras	700	80	56,000	–	–
	Mounting brackets	40	80	3,200	–	–
	Wooden posts	2	80	160	–	–
	Dog training to certification level	15,000	–	–	2	30,000
	Purchase of dogs	1,000	–	–	2	2,000
	Sub-total			59,360		32,000
Operating	Batteries	1	960	960	–	–
	Memory cards	12.50	80	1,000	–	–
	Camera deployment and retrieval (per day)	350	8	2,800	–	–
	Collation of camera results (per day)	350	2	700	–	–
	Vehicles (per km)	0.8	800	640	400	320
	Dog team (per day)	2,300	–	–	10	23,000
	Upkeep of dogs (per day)	5.5	–	–	20	110
	Sub-total			5,100		23,430
	Total			**65,460**		**55,430**