Conservation detection dog is better than human searcher in finding bilby (*Macrotis lagotis*) scats

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ABSTRACT

Conservation detection dogs have been widely used for finding scats, retreat sites and specific plant and animal species for a variety of purposes, including monitoring, management, biosecurity and eradication programs. Their cost-effectiveness appears well established in finding cryptic and rare animals, yet they are not included in the Department of Biodiversity, Conservation and Attractions' published search protocol for bilbies. In this study a human searcher located six of 90 scats (6.7%) compared to the conservation detection dog that located 89 of 90 bilby scats (98.9%). The dog's time to locate the first scat in a 25m x 25m site with a ground cover of leaves, sticks and grasses was 72.8 sec (± se 8.10, n = 60) and, when a second scat was present, the mean time to locate the second scat was 186.5 sec (± se 186.517, n = 29). We strongly recommend that conservation detection dogs are incorporated into the State government's search protocol for bilbies, as they are more accurate and faster than human searchers, and provide development proponents with greater confidence in searches undertaken as part of an environmental impact assessment.

Key words: Scats, Western Australia, survey guidelines, searching, threatened species, government survey guidelines

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Introduction

Dogs have been used for centuries to locate objects or persons with a scent because of their olfactory acuity, and in more recent times they have been extensively used to locate a variety of cryptic and concealed items such as narcotics (Jezierski *et al.* 2014), explosives (Porritt *et al.* 2015), blood residue (Rust *et al.* 2016), human remains (DeGreeff *et al.* 2012; Dilkie and Veniot 2017), plants (Anglada and Torras 2016; Goodwin *et al.* 2010; Vesely 2008), invertebrates (Mosconi *et al.* 2017; Suma *et al.* 2014), human medical conditions (Guirao Montes *et al.* 2017; Los *et al.* 2017) and wildlife (Arandjelovic *et al.* 2015; Beckmann *et al.* 2015; Beebe *et al.* 2016; Chambers *et al.* 2015; Cristescu *et al.* 2015; de Oliveira *et al.* 2012; Glen *et al.* 2016; Glen *et al.* 2018; Nielsen *et al.* 2016; Orkin *et al.* 2016; Reindl-Thompson *et al.* 2006; Vynne *et al.* 2009, 2011; Wasser *et al.* 2009). There have been multiple reviews and commentaries on detection dogs' capabilities and roles [see Browne (2006), Johnen *et al.* (2013), Beebe *et al.* (2016), Hayes et al. (2018), Wilson and Coleing (2018) and Cristescu *et al.* 2019], so it is not our intention to repeat these reviews here.

The Western Australian Department of Biodiversity, Conservation and Attractions (DBCA; 2017; also see Southgate *et al.* 2018) has a published protocol for searching for evidence of bilbies based on randomly selecting a small number of 2 ha plots that are searched by humans. We do not support this protocol because if a development proponent indicates that bilbies are not present, then both the proponent and government regulators would expect that they are not present. A sampling approach, particularly using a small sample, could fail to detect the presence of bilbies that are in very low density in a potential development site, with the resulting erroneous conclusion that they are not present and no referral is required under the *Environment Protection and Biodiversity Conservation Act 1999*, which could have serious consequences for the proponent if bilbies are subsequently found to be present in the area and will be significantly impacted by the proposed development. Detection dogs have been demonstrated to have higher detectability levels than human and other search strategies (Arandjelovic *et al.* 2015; Cristescu *et al.* 2015; Nielsen *et al.* 2016; Orkin *et al.* 2016; Thomas *et al.* 2020), but are not a recommended method for bilby searches and have rarely been used to find animals in Western Australia. Although they have been widely used (e.g. koala - *Phascolarctos cinereus*, Cristescu *et al.* 2015; quolls - *Dasyurus maculatus,* Leigh and Dominick 2015; bristlebirds - *Dasyornis brachypterus,* Office of Environment and Heritage 2015; rabbits - *Oryctolagus cuniculus,* Robinson and Copson 2014; cats - *Felis catus,* McGregor *et al.* 2016; cane toads - *Rhinella marina,* Thompson and Trevaskis 2018; rats - *Rattus rattus,* Glen *et al.* 2018, Lord Howe Island Rodent Eradication Project 2018; hawkweed - *Hieracium* sp. Office of Environment and Heritage 2016) in the eastern states of Australia, offshore islands and New Zealand.

It is our perception that further affirmation of conservation detection dogs' ability was needed to facilitate a more widespread acceptance of their role in conservation and management of vertebrate fauna, particularly for rare and threatened fauna. We therefore undertook this study to test the ability of a trained conservation detection dog to find cryptic bilby scats using its olfactory ability and to compare its efficiency with the results of human searches for the same scats, given that they were not included in the DBCA's (2017) search protocol for bilbies.

Methods and materials

Detection dog

A female Springer Spaniel (Dazzy – Figure 1) that had previously been trained to find scat scents for bilby (*Macrotis lagotis*), northern quoll (*Dasyurus hallucatus*), feral cat (*Felis catus*) and fox (*Vulpes vulpes*) was used. This dog was approximately two years old and was initially trained by Steve Austin (https://www.steveaustindogtrainer.com) and is now handled by ST (primary author). Dazzy is typically used to locate fox and cat scats for feral animal control programs in urban and peri-urban areas.

Bilby scats

Bilbies regularly deposit their very characteristic scats in or near their diggings and small piles (i.e. 3-5 pellets) are generally dispersed over a wide area (Southgate *et al.* 2018; Thompson and Thompson 2008).

Bilby scats were provided by the Perth Zoo and Kanyana Wildlife Rehabilitation Centre. Scats collected by Zoo staff were kept frozen in plastic bags until there was sufficient quantity to warrant collection by one of the authors. The authors collected recently deposited bilby scats from their enclosures at the Kanyana Wildlife Rehabilitation Centre and they were stored in plastic bags in the freezer. All frozen scats were left in the freezer until they were used in these trials, at which time they were thawed immediately before use. Storage of frozen scats ranged from two weeks to over 12 months and scats came from male and female bilbies.

Study site

The geographic range of bilbies has significantly contracted in the last half century (Abbott 2001),

Figure 1: Dazzy, the conservation detection dog, passively indicating on scats during a search. Photo credit: Terrestrial Ecosystems

and its range is now largely restricted to sandy desert areas of inland Australia (Department of Sustainability, Environment, Water, Population and Communities 2013). In its former range it occupied a wide variety of habitat types, but is now predominantly found in spinifex shrublands and woodlands on a sandy-clay substrate (Southgate *et al*. 2019). Ground cover is therefore often leaf-litter on a sandy or sandy-clay substrate, which is similar to that used in this trial.

The location selected for these trials was a relatively flat area (160 m by 160 m) that had previously been used for agisting horses in urban Perth, Western Australia (31.96°S 115.79°E). Four 25m x 25m sites (set out as 2 x 2 matrix) were marked with a metal stake at each of the corners; these sites were approximately 20–50 m apart.

Site one had eucalypts (*Eucalyptus gomphocephala, E. camaldulensis*) planted along two sides of the square. It was almost flat with approximately 80% ground cover of leaves and grasses. Trees immediately adjacent to the boundary and nearby contributed to leaf litter in the site.

Site two had two planted eucalyptus trees (*E. gomphocephala*) along one side, was even and gently sloping from east to west. It had approximately 40% ground cover with a moderately dense leaf-litter and sparse grasses.

Site three was gently sloping from east to west with three planted eucalypts (*Corymbia maculata*). Approximately 95% of this site had a dense ground cover of leaves and low grasses, and low shrubs to approximately 15cm high over approximately 45% of this site.

Site four was relatively flat and contained four Peppermint trees (*Agonis flexuosa*), two upright dead trees, one fallen dead tree, and two eucalypts (*E. gomphocephala, E. camaldulensis*). It had approximately 75% dense ground cover of leaf-litter and 2% cover of low shrubs (≤15 cm high).

Straw-necked Ibis (*Threskiornis spinicollis*), White Ibis (*Threskiornis moluccus*), Little Corella (*Cacatua sanguinea*) and other avifauna were regularly observed foraging in sites three and four. Scats and feathers from these birds were present and provided distraction scents.

Trials

Target scats were randomly allocated to the four sites at either 1 or 2 locations. A realistic natural scat deposit (i.e. 3-5 pellets) was placed at one or two locations by a person not involved in this research for each trial. Forceps (30 cm long) were used to deploy and collect all bilby scats. Each site was divided into 1 m by 1 m squares and numbered from 1-25 along both the X and Y axes. One or two sets of two numbers (i.e. for 1 or 2 scats being deployed) between 0 and 25 were randomly allocated (using Microsoft Excel 'randbetween' function) to each trial to specify the location of scat(s). Each set of two numbers indicated the specific grid along the X and Y axis the scat was deployed in, always starting from the same corner. The 90 scat locations for the 60 trials were predetermined before any trial commenced.

The four sites were searched on a single day by one of the authors (GT), and then followed by the conservation detection dog two to five hours later. The author (GT) that searched the sites and the dog handler did not know the location of the scats nor the number of scats in each site until all four sites had been searched during a session. The search procedure was repeated over 15 days between 31 March and 10 June 2018 (see Table 1 for trial dates, and maximum and minimum daily temperature and rainfall on trial days).

The human searcher (GT), who had previous experience in searching for and locating bilby scats (see Thompson and Thompson 2008, and had searched at multiple locations over 10 years as part of EIA assessments in the Pilbara of Western Australia), searched each of the four sites for a maximum of 10 minutes by slowly walking a series of ordered transects. Ten minutes was selected as it was considered by the authors a reasonable time for a human to search each site, it far exceeded the 25 minutes specified by DBCA (2017) for human searches of 2 ha plots for bilby signs and was considered adequate for a detection dog to thoroughly search the area. When a scat was found by the human searcher, its location and the time taken were recorded, but the scat pile was not touched.

Table 1. Trial days showing maximum and minimum temperatures and rainfall for each trial day (from: http://www.bom.gov.au/climate/dwo/IDCJDW6121.latest.shtml)

Trial date	Maximum °C	Minimum °C	Rainfall mm
31/03/2018	23.3	17.5	0
03/04/2018	30.2	19.7	0
11/04/2018	22.9	16.7	0
14/04/2018	20.3	11.7	0
20/04/2018	23.1	13.4	1.4
23/04/2018	22.2	11.4	7.8
02/05/2018	19.3	17.4	0
07/05/2018	20.6	13.3	0.2
09/05/2018	24.2	12.3	0
11/05/2018	29.2	16	0
12/05/2018	30.4	18.8	0
14/05/2018	26.2	15.4	0
23/05/2018	28.1	13.5	0
29/05/2018	20.4	9.6	0.6
10/06/2018	20.3	8.5	0.4
Mean	**24.05**	**14.35**	**0.69**
SE	**0.99**	**0.86**	**0.52**

After the sites were searched by GT, and between two and six hours after the scat piles were laid out, the conservation detection dog was deployed to find the scat piles. The dog's handler (ST) would sit the dog at the boundary of a site and command the dog to search. The handler used a whistle and hand signals to direct the dog to search all areas of the site. When the dog located a scat pile, it would respond with a trained alert which was to assume the prone position with its nose approximately 5-10cm from the scat. When the handler confirmed the search success, the dog would be given the bridging command (i.e. 'yes') and a tennis ball was thrown for it to retrieve two or three times as a reward before the dog was directed to continue the search. The time to locate the scat was recorded, and the scat pile was immediately removed from the site by the recorder (GT), to avoid the dog finding the same scat pile a second time. This search was repeated until either a second scat was found, or the handler was convinced the dog had adequately searched the area and there was no second scat. If a second scat was found, then the trial was stopped. No dog search trial ever reached the allocated maximum 10 minutes. The timing clock, once started, was not stopped until the second scat was found, or the handler signalled the trial was concluded (i.e. the time included when the dog was receiving its reward or getting a drink). The time to locate the second scat therefore included non-searching time (e.g. dog was being rewarded) but reflected the situation where a dog was searching for multiple scats in the field. The dog was able to drink from a water container left on the edge of the site at any time during each trial. Scats were removed after the search by the detection dog and new scats used for the next trial.

Statistical analyses

We compared the number of scats found by the human and dog searches, in each of the 60 trials, using a paired t-test (statistiXL, www.statistixl.com). We provide the 95% confidence limits using the Jeffreys interval method (Brown *et al*. 2011) for the proportion of correct responses for the conservation detection dog and the human searches.

To analyse the time taken to locate the first scat, we used a linear mixed effects model with location (sites 1-4) as a fixed categorical factor, and the repeated measurements over 15 consecutive days as a random factor, with the lmer function in library lme4 (Bates *et al.* 2014), using R (R Core Team 2018) and RStudio (RStudio Team 2015). To evaluate the significance of the repeated time factor, we compared models without and with the repeat, using the lm function, and the lme function in library nlme (Pinheiro *et al.* 2015) with Satterthwaite's method for estimating denominator degrees of freedom of these mixed effects models (Kuznetsova *et al.* 2017).

Results

The human search of the sites located six of 90 scats (6.7%; 95%CI = 2.83 – 13.22). Two scat piles were located in one trial, and four of the six scats were located in areas with no leaf litter or grasses (i.e. bare ground). The conservation detection dog located 89 of the 90 scats (98.9%; 95%CI = 94.93 – 99.88); it located a scat pile in every trial and located both of the scat piles in 29 of 30 trials. There was a highly significant difference between the number of scats located by the conservation detection dog and the human searches (t_{59} = 19.3, $P < 0.001$). There were no false positives for the dog or human searches.

The mean time to locate the first scat in the human search was 361.2 sec (± se 51.8; n = 5). The dog's mean time to locate the first scat was 72.8 sec (± se 8.10, n = 60) and the dog's mean time to locate the second scat was 187 sec (± se 186.5, n = 29), which includes reward time for finding the first scat. There was a highly significant difference between the human and dog search times for the first scat pile (t_{63} = 5.52, $P < 0.01$). The human search data are not analysed further, because of the low success rate.

For the time taken to locate the first scat pile by the conservation detection dog, there was no difference between the four sites ($F_{3,45}$ = 0.402, $P = 0.752$). There was no significant difference in a comparison of the two models with and without 'day' as a repeat factor for the 15 trials (X^2_1 = 0.074, $P = 0.786$; i.e. there was no significant effect of day of sampling).

Discussion

Knowledge of the presence and location of rare, elusive and threatened species is fundamental to the preparation of appropriate protection and fauna management strategies or reporting on the presence or absence of conservation species in environmental impact assessments. For some species, this can be difficult and time consuming, particularly when the species are in low density, occupy habitat(s) that are difficult to search, or have a large home range in which some areas are only visited periodically. The location of a species' scats, and in particular, recently deposited scats, is an effective method of determining both presence and relative abundance for some species (Putman 1984; Wayne *et al.* 2005; Wilson and Delahay 2001).

The capacity of the conservation detection dog in this study to locate 98.8% of scats compared to 6.7% of scats found by a human searcher clearly demonstrates the superior search skills of a trained conservation detection dog to find a cryptic scat. Not only did the conservation detection dog find significantly more scat piles, but it found the first scat pile significantly faster (72.8 sec compared with the human search that took 361.6 sec). There was no improvement in detection time over 15 consecutive trials, suggesting that there was no additional training effect of repeated searching.

The capacity of conservation detection dogs to locate the faeces of rare and elusive species has been well documented (Cristescu *et al.* 2015; de Oliveira *et al.* 2012; Orkin *et al.* 2016; Vynne *et al.* 2011). In a similar manner to this study, de Olivera *et al.* (2012), Cristescu *et al.* (2015) and Orkin *et al.* (2016) demonstrated significantly higher accuracy and faster search times for conservation detection dogs to find a cryptic scat compared with a human's ability to find the same scat. For example, Cristescu *et al.* (2015) used a detection dog to find low density koala scats in eucalypt bushland on North Stradbroke Island, Queensland. In 150 trials where the scat location was known only to a third party, the conservation detection dog found 146 scats (97% detection rate), which is similar to the results of this trial. The human detection rate was 93%, far higher than in this trial, suggesting koala scats were less cryptic than bilby scats in the selected search habitats. The conservation detection dog had 24% less false negative results and was 153% more accurate than the human observer. In this koala study, the detection dog was 19 times faster than human only searches. This supports the evidence that dogs can be more time effective than human searchers in the search for rare and cryptic species. Time saved in searches reduces the overall cost of projects, and when dog verses human searches are compared, the cost saving is appreciable. However, in a cost-effectiveness comparison between human and dog searches, consideration must be given to the added investment required to train and maintain a conservation detection dog (Glen *et al.* 2016; O'Connor *et al.* 2015). In addition, a conservation detection dog must be thoroughly tested prior to use otherwise it may provide erroneous results (i.e. false positives and negatives). In some circumstances, it may be appropriate for human searchers to also be trained and tested.

Alternatives to detection dogs

Conservation detection dogs' detection rates have also been compared with alternative detection methods. For example, Long *et al.* (2007) concluded detection rates of conservation detection dogs were superior to remote camera traps and hair snares to detect black bears (*Ursus americanus*), fishers (*Martes pennanti*) and bobcats (*Lynx rufus*), and Wasser *et al.* (2012) reported a detection dog was more effective than human surveys detecting owls using vocalisation.

A recent paper by Southgate *et al.* (2018) on verifying and sampling for the presence of bilbies recommended aerial surveys or human searching of randomly allocated 2 ha plots. Southgate *et al.* (2018) acknowledged the many problems associated with detecting bilby signs when using human searches (e.g. false absence, false presence, unsuitable habitat to register signs, inappropriate weather, age of signs etc) and the need to ground-truth aerial surveys because of the high proportion of false-presence and false-absence errors. We propose that the use of a detection dog addresses many of these sources of error and is likely to be a more time-effective and cost-effective method for environmental consultants and researchers.

In addition to searching for scats and retreat sites, conservation detection dogs can also be used to track animals. For example, McGregor *et al.* (2016) used a Springer Spaniel and Catahoula Leopard Hound to track feral cats and concluded that in terms of person-hours involved, spotlighting with dogs was six times more efficient than leg-hold trapping. This is a particularly useful ability in finding retreat sites for feral species that are to be euthanased (e.g. foxes and feral cats) or in the determination of retreat sites for a wide range of species.

Humans undertaking visual searches for cryptic scats are often constrained by the presence of leaf-litter and vegetation, as was the situation in this study. This is generally less of a limitation for a dog. For example, Leigh and Dominick (2015) reported no significant difference for a trained conservation detection dog finding spotted quoll (*Dasyurus maculatus*) scats in three habitat types (i.e. open grassland, woodland, dense heath) in both winter and summer conditions in New South Wales, Australia. This suggests that a conservation detection dogs' performance is robust to changes in vegetation density, if allowances are made for increased search time in denser habitats. In our study, there was no difference in dog detection times for four sites differing in vegetation cover.

Management implications

Searching for rare, difficult to locate, wary, shy and cryptic species for research or environmental assessment purposes can be expensive. For example, the Western Australian DBCA (2017) has issued survey guidelines for bilbies and this document includes the following information for the preferred bilby search method of 2 ha areas - 'The standardised 2 ha sign plot method provides systematically quantified data and is important to produce directly comparable data with that from the surrounding region, other sites, or over time. It involves searching multiple 2 ha plots for bilby sign, for 25 minutes. In smaller areas, a density of 2-4 plots per 100ha, or alternatively less plots with supplementary linear searches, should be applied. As the project area size increases, plot spacing may be increased. If sampling independence is required, plots need to be spaced more than 4km apart. Plot locations need to be distributed to include all suitable bilby habitat and a range of fire ages.' For an environmental practitioner to say bilbies are not present in a potential development site, when they are present (Type II error), results in a project that is not adequately assessed and a population of a threatened species without adequate management.

To illustrate the time-effectiveness, and thus cost-effectiveness of a conservation detection dog in searching for scats, burrows and bilbies, we have assumed the area to be investigated is 1,000 ha (i.e. size of a small mining pit in the Pilbara of Western Australia); 2 ha plots are randomly allocated and searched and the hypergeometric distribution is an appropriate tool to determine probabilities and sample sizes. If it is assumed that all signs of bilbies have a detectability = 1 (which our results and field experience show is not the case), then, 495 2 ha plots would need to be searched to be 99% confident that bilbies were absent. The Department (2017) recommend each 2 ha plot search should take 25 minutes, which is more than ten times faster than the search speed used in our trials and faster than we would search an area in the field. Even at this speed, the total search time to be 99% confident that bilbies are not present is 198 hrs. Our detection dog was 4.9 times faster in finding the first scat than the human searcher, but the human only found 6.7% of scats compared with the dog that found 98.9% of scats, making it difficult to compare efficiency. However, if a conservation detection dog was as efficient at finding bilby scats as Cristescu *et al*.'s (2015) dog was in finding koala scats (i.e. 19 times), then the search time can be reduced from 198 hrs to 11 hrs. This is a considerable cost saving for a development proponent, which is a strong justification for the use of a conservation detection dog. In addition, the conservation detection dog is also likely to increase the detection probability.

Conservation detection dogs are now widely used for a variety of purposes and a wide range of wildlife applications (see reviews; Beebe *et al.* 2016; Johnen *et al.* 2013). Conservation detection dogs are not novel and have demonstrated their value as a tool for finding rare and elusive species. Ensuring that dogs are adequately trained and working in an environment that understands the strengths and limitations of this research tool is vital for their ongoing success. We strongly encourage environmental consultants, researchers, pest managers and threatened species managers that undertake fauna surveys and assessments, and species-specific searches to become familiar with the capabilities of a suitably trained conservation detection dog in searching for wildlife and consider their application into the field of conservation. We strongly recommend the DBCA's protocol for bilby searches be amended to give preference to conservation detection dog searches.

Conflicts of interest

Two of the authors (ST and GT), are Partners in Terrestrial Ecosystems which owns the conservation detection dog.

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