Rapley *et al. Animal Biotelemetry* (2026) 14:9
https://doi.org/10.1186/s40317-026-00448-2

Animal Biotelemetry

RESEARCH Open Access

Novel application of a conservation detection dog to recover wildlife telemetry equipment

Shoshana Rapley[1*], Heather M. McGinness[2], Claudio Sillero-Zubiri[3], Micha V. Jackson[2], Maldwyn J. Evans[1], Iain J. Gordon[1,4,5], Robert Heinsohn[1] and Adrian D. Manning[1]

Abstract

Background Wildlife tracking technologies are increasingly used to study animal behaviour, inform conservation management, and answer fundamental questions in ecology. However, a drawback to wildlife telemetry is that equipment is expensive and can be difficult to retrieve when lost in the field, leading to loss of data and inefficient use of project resources. As a potential solution, we began training dogs to search for and locate GPS tracking devices by scent. This approach targets the odour of the device itself, rather than the animal carrying the device. Here, we report on the training, deployment and evaluation of a wildlife telemetry detection dog.

Results During field deployments, the detection dog successfully recovered $11,200 AUD worth of lost GPS devices over a 16-month period. In a controlled field evaluation, the detection dog located 100% of targets compared to 43% by the human-only search. The detection dog was significantly faster, with an average search time of 6.4 min (± 1.5 SE, $n = 17$) compared to 43.9 min (± 4.9 SE, $n = 14$) for human-only searches. Combining detection rate and search speed, the detection dog was 16 times more efficient.

Conclusions This is the first reported use of a detection dog to recover wildlife telemetry devices. The detection dog significantly improved device recovery efficiency, with benefits including reduced project costs and improved data completeness. This approach has broad applicability across diverse species and contexts, particularly when visual searching is inadequate such as in dense vegetation or when equipment is buried underground. This novel method offers a practical solution to equipment recovery challenges facing wildlife tracking programs worldwide.

Keywords Animal tracking, Biotelemetry, Conservation dog, Detection dog, Wildlife telemetry

Background

Wildlife telemetry is a critical tool in animal research that is reshaping the fields of ecology and conservation [1, 2]. Wildlife telemetry relies on animal-borne devices (also known as 'tags' or 'biologgers') that record a diverse array of measurements, with geographical location being the most widely used (generally via VHF or satellite tracking), as well as movement behaviours, physiological parameters, and environmental data [3–5]. Retrieving telemetry equipment post-deployment is essential when data is stored onboard. Failed retrieval can reduce sample sizes and jeopardise study objectives [6]. Even when

*Correspondence:
Shoshana Rapley
shoshana.rapley@anu.edu.au
[1]Fenner School of Environment and Society, The Australian National University, Canberra, ACT, Australia
[2]Commonwealth Scientific and Industrial Research Organisation, Canberra, ACT, Australia
[3]Wildlife Conservation Research Unit, Department of Zoology, University of Oxford, Oxford, UK
[4]College of Science & Engineering, James Cook University, Townsville, QLD, Australia
[5]Research Division, Central Queensland University, Rockhampton, QLD, Australia

data are remotely transmitted, retrieval can be necessary to maximise the knowledge gained. If the tracked animal has died, recovering its tracking device can enable determination of the cause of mortality, which is highly valuable information for ecological research and conservation strategies [7, 8]. Furthermore, it is important to monitor whether the device itself is implicated in the mortality event, to inform robust ethical use of the technology [9]. In addition, retrieval of the device allows interrogation of the mode of attachment (e.g., backpack, collar) to help evaluate whether it is working as intended and inform modifications to the design [10]. Lastly, these devices are expensive [e.g., a recent review of shorebird tracking options put the upper cost of a single GPS telemetry unit at AUD$6000; 11], and retrieved devices can often be redeployed, thereby using project resources efficiently [12].

While retrieval of wildlife telemetry equipment is important, locating devices in the field can be challenging. Devices are often small, typically less than 3–5% of the animal's body weight [2, 13] with some now available as small as 1.3 g [14]. They are also intentionally inconspicuous, being neutrally coloured or matching the colouration of the study animal to reduce the risk of predation of the study animal as a result of the tag [8]. These features make it difficult for humans to locate lost equipment. Complex environments with dense vegetation and difficult terrain compound this problem. When predation or scavenging of the study animal occurs, the predator may cache the device and carcass in vegetation, logs, or underground (authors' observations). Even when using precise GPS tracking that allows refinement of the search area, devices can remain difficult to find due to location error and device visibility. For example, the average location error of Telonics GEN3 GPS devices, tested under field conditions for Puma (*Puma concolor*) tracking in Arizona, was 40.81 m [15]. The search area for a missing device in this example would be 5,232 m^2 (just over half a hectare). Consequently, searching for telemetry equipment can be time consuming and incur costs in terms of personnel time and transport [12], with high rates of failure.

Detection dogs (*Canis lupus familiaris*) locate targets by scent and frequently outperform alternative methods in their efficiency and precision [16, 17]. Detection dogs have been used to find a range of biological (e.g., humans, wildlife, and diseases) and non-biological (e.g., pollutants, explosives, and narcotics) odours, and their use has expanded rapidly in the last two decades [18]. Dogs can detect odours at concentrations as low as one part per trillion [19] with sensitivity as high as 100% [17, 20]. Wildlife detection dogs have been used to locate rare and threatened plants and animals and their traces (e.g., scat, pellets), and to assist in control or eradication projects of threatening processes (e.g., invasive predators, pathogens, weeds), making them a valuable tool in conservation programs [21–25]. The terms 'wildlife detection dog' and 'conservation detection dog' have been used interchangeably [16]; however, detection dogs are increasingly used to locate non-biological targets for conservation purposes, such as poisoned baits and poaching equipment, including snares, traps, weapons and ammunition [26, 27].

During bird tracking research in south-east Australia, we encountered the challenge of recovering lost wildlife telemetry equipment [10, 28–32]. As a potential solution, we explored the efficacy of using conservation detection dogs to locate tracking devices by scent. We predicted the detection dog would outperform the alternative method of human-only searching in both sensitivity and efficiency. Here we report on the training, deployment and evaluation of a wildlife telemetry detection dog. Importantly, training targeted the odour of the tracking device itself, rather than the animal carrying the device.

Methods

Study context

We tracked birds in two research projects: waterbird movement ecology in the Murray Darling Basin and the reintroduction of the bush stone-curlew (*Burhinus grallarius*) in south-east Australia. The purpose of the waterbird project was to address knowledge gaps in waterbird ecology to inform water allocation and wetland management, and involved long-term satellite tracking of aggregate-nesting waterbirds [10, 28–30, 32]. Tracked species included straw-necked ibis (*Threskiornis spinicollis*), Australian white ibis (*T. molucca*), royal spoonbill (*Platalea regia*), great egret (*Ardea alba*), and plumed egret (*A. plumifera*). More than 200 waterbirds were tracked with GPS devices between 2016 and 2025. Waterbirds were caught and fitted with GPS tracking devices during breeding events in wetlands across the Murray Darling Basin. Birds subsequently dispersed across eastern Australia and as far north as Papua New Guinea [28–30]. We used a range of solar-powered GPS models, manufactured by Druid (Druid Technology Co., Ltd., Chengdu, China), GeoTrak (GeoTrak Inc. North Carolina, USA), and Ornitela (Ornitela, UAB Vilnius, Lithuania). Attachment methods varied by species. We used wing-loop 'backpack' harnesses with a weak-link at the keel for ibis and some spoonbills and leg-loop harnesses for egrets and spoonbills [10, 28–30].

Bush stone-curlews were translocated to three sites: Mulligans Flat Woodland Sanctuary in the Australian Capital Territory (ACT), Mt Rothwell Biodiversity Interpretation Centre in Victoria, and Orana Park in Victoria [33]. Satellite tracking was used to monitor the fates of released birds and develop an understanding of their

movement ecology in their reintroduced range [31, 33]. A total of 79 bush stone-curlews were tracked from 2019 to 2025, including translocated individuals and their wild-born offspring. Bush stone-curlew movements were mostly local, with some travelling to nearby New South Wales (NSW), but one travelled 600 km north to the Hunter Valley (S. Rapley, unpublished data). All bush stone-curlews were fitted with solar-powered Ornitrack-20 3G GPRS devices (Ornitela) using wing-loop 'backpack' harnesses with a weak-link at the keel [31].

Telemetry equipment went missing when devices detached from the birds (e.g., due to planned failure of the weak-link mechanism) or when birds died due to predation, disease, and other causes. Recovery of the devices was deemed desirable both for redeployment on new birds (thus avoiding the expense of purchasing new devices) and for gaining information about the circumstances around end of deployment (e.g., likely cause of bird death; performance of the weak-link mechanism). This challenge inspired the use of detection dogs to improve GPS device recovery outcomes. The first dog trained in GPS detection was 'Rohan' (trained and owned by author HMG). Later, 'Koda' (trained and owned by author SR) was trained in GPS detection and is the subject of this study. Rohan passed away prior to this study and is not included in the evaluation. All results presented here refer only to Koda.

Training protocol

This section describes the training protocol used in this study. Its intent is to aid understanding of the approach used and evaluation of the results of this study, but is not intended as a comprehensive training guide for other projects. Training approaches will always vary based on individual dog aptitude and personality, the target odour, trainer experience, and preferred methodology. As such, the precise timing and parameters used here should not be seen as prescriptive for future studies.

Koda (Fig. 1), a female Australian Kelpie cross born in March 2021, was trained and handled by author SR. She possessed qualities suitable for detection work: highly play motivated, intelligent, physically fit, and demonstrating a good balance between focussing on the handler and independence while working [see 34]. The dog was trained on solar-powered Ornitrack-20 3G GPRS devices in the colour grey. Initially, new devices from storage were used in training (n = 20). Later, we included devices that had been retrieved from deployments on bush stone-curlews (n = 14). The training approach followed established methods using shaping, which involves incremental progression toward desired behaviours through positive reinforcement [35, 36]. The first step was to teach the dog to associate the target odour with a reward (e.g., food or play), for which we used a shaping exercise where the dog was rewarded for choosing to sniff and engage with the target. Next, we developed an alert behaviour at the source of the target odour. The dog in this study performed a 'drop and point' alert, characterised by

Fig. 1 'Koda' the detection dog. Photograph with permission from Nic Vevers, the Australian National University.

lying down facing the odour with nose pointed toward or touching the target. This was the alert naturally given by the dog during shaping exercises. Finally, we built up a strong history of positive reinforcement through repetition. Initially, training occurred in the low-distraction environment of the home, and we gradually increased the difficulty of the search by practising in a variety of environments with increasing levels of distraction (e.g., driveway → yard → bushland at home → bushland away from home). Progressive training through environments of increasing distraction ('proofing') is a standard working dog training principle, and what constitutes low versus high distraction varies between individual dogs. As is typical for many dogs, Koda found practice in familiar environments less challenging than practice in novel environments with unfamiliar background odours. We also trained the dog to a high proficiency in the following actions: recall, following handler-directed changes in direction (e.g., to direct the dog into the search area), and emergency stop [per recommendations made by 37].

Training commenced in July 2021 when Koda was four months old, with her first field retrieval occurring in October 2021. However, this four-month period should not be interpreted as a discrete 'training window', because training continued beyond this point with ongoing skill development for both dog and handler. Initial training sessions lasted 5–30 min and occurred 1–3 times per week, progressing to sporadic practice sessions once operational proficiency was achieved. Training sessions served dual purposes as both skill development and mental enrichment, and were integrated into Koda's routine care rather than conducted as isolated training events.

We recognise that cost estimates are critical for project planning [38]. However, precise financial accounting is not possible in this case because Koda is a privately owned companion animal whose care was not separately budgeted from household expenses, and training occurred during the owner/handler's personal time. This scenario of researcher-owned detection dogs is not uncommon in academic settings [authors' observation and e.g., 39].

Field retrievals

Between October 2021 and February 2023, we deployed the detection dog and handler (hereafter dog-handler team) to retrieve seven telemetry devices located in the ACT and NSW. All of the retrieved devices were solar-powered Ornitrack-20 3G GPRS units in the colour grey that had been fitted to birds with Teflon-ribbon backpack-style harnesses [29, 31]. Six of the devices had been deployed on bush stone-curlews and one on a straw-necked ibis.

Controlled performance evaluation

We conducted a controlled performance evaluation to assess the sensitivity, precision, and efficiency [Table 1; definitions from 40] of the dog-handler team and compared this with human-only searches to quantify relative effectiveness. We conducted an a priori power analysis to determine the required number of trials. We used the function pwr.2p.test() from the package 'pwr' [41] in R version 4.4.1 [42]. Based on prior field experience, we estimated the dog's detection rate at 85% (range: 70–100%) and human-only detection at 35% (range: 20–50%). Using a one-sided test ($\alpha = 0.05$, power = 0.8), these estimates indicated 3–73 trials (mean = 16) would be required, depending on the true difference in detection rates. We planned to conduct 20 trials per method, with interim assessment to refine the number of trials needed. After 15 dog-handler team trials with 100% success, we determined six human-only trials would provide adequate power, but wanted to conduct more than six for repetition with multiple human searchers. We conducted 20 dog-handler team searches and 14 human-only searches (seven people, two trials each) in April–June 2025. The human-only search volunteers had either previous experience locating GPS devices in the field ($n = 3$ volunteers) or experience searching for cryptic and difficult to detect targets ($n = 4$ volunteers) such as threatened forbs, invertebrates, or reptiles.

We selected a 625 m² search area (1/16 hectare) as representative of realistic search extents for Ornitela GPS devices. These devices have reported location accuracy of 8.0 ± 24 m [mean ± SD, 43], producing theoretical search areas of 201–1810 m². Our chosen area was challenging enough to test dog performance while avoiding excessively long human searches (> 1 h).The evaluation took place in grassy woodland (overstory dominated by *Eucalyptus rossii* and ground cover dominated by *Rytidosperma pallidum*), with vegetation and terrain complexity that was representative of challenging field conditions

Table 1 Performance metrics for detection dog evaluation as defined by Bennett et al. [40]

Term	Definition	Calculation
Sensitivity	Proportion of targets found relative to the total number of targets available	$\frac{True\ Positive}{True\ Positive+False\ Negative}$
Precision	Proportion of alerts that correctly identify a true target. That is, how well the dog distinguishes the target odour from other odours	$\frac{True\ Positive}{True\ Positive+False\ Positive}$
Efficiency	Performance per unit effort, where effort is the duration of a search	$\frac{Sensitivity}{Effort}$

(Fig. 2). We chose to emulate challenging realistic conditions, rather than a simpler open-field test, because detection performance can vary with habitat complexity [44].

We used a blind search protocol where presence/absence and location of the device was known by a field assistant but not known by the dog-handler team or the human-only searcher. The design was not considered to be double blind. However, the field assistant was not within the search area during the trial, thereby excluding the type of single-blind bias in the medical literature where tests take place in laboratory settings with an observer present that could inadvertently cue the dog [20]. For the dog-handler searches, the GPS was placed at least two hours prior to the search to allow an odour plume (evaporated odour compounds dispersing from the source material due to surrounding air currents [45, 46]) to develop [47]. To set up the trial, the field assistant stood at the perimeter of the marked search area and threw the device into the marked search area in a random direction. The device placements varied from the centre to the boundary of the search area and were randomly distributed. Throwing from the perimeter avoided creating a trail of human odour that the dog could follow to the device location. We handled the device in its plastic storage packaging to reduce human odour on the device before placement. We used different devices for each search, and none were the devices used in training.

To assess the rate of true negatives and false positives, we did not place a device in 15% of the dog-handler trials (i.e., absence trials). All human-only searches included a placed device. We limited the search time to one hour. A trial was determined to have no target once the dog-handler team had covered the entire search area without an alert and the handler called an end to the search. The dog was not trained to give a formal 'no target' alert behaviour, as used in laboratory studies with scent line-ups. However, she displayed different body language in trials with a target compared to those without, which informed the handler's decision to call the end of a search. For example, when on target odour, the dog worked with a swift, taut gait and ranged out from the handler; comparatively, after clearing a search area and not identifying odour, she moved with a slower, looser gait and often returned to the handler.

We only conducted evaluations during mild weather conditions between 10 and 25 °C and recorded the predicted temperature and wind speed for the evaluation location (Sutton, NSW) from AccuWeather. We collected weather data to ensure searches occurred under similar conditions, but did not include these as variables in our analysis. We used predicted weather data because the nearest weather station (Canberra Airport, ACT), while only 10 km away, is 110 m lower in elevation and on the other side of a hill range, so could vary considerably from real field conditions. The direction of search was always into the wind.

Fig. 2 Terrain and vegetation of the controlled performance evaluation search area

We compared search times between dog-handler and human-only searches using a one-sided Student's t-test in R version 4.4.1 [42], testing the hypothesis that dog-handler searches would be faster. We excluded absence trials from this comparison because these were not conducted for human-only searches. We visualised results using the R package ggplot2 (Wickham 2014).

Results

Field retrievals

Between October 2021 and February 2023, the dog-handler team successfully located seven GPS devices in field retrievals (Fig. 3; Table 2). In four cases, a human-only search had already failed to locate the device before the dog-handler team's attempt. In two cases, the dog-handler team searched in the wrong area on the first attempt (due to large GPS errors in the most recent fixes available) but succeeded on the second attempt with revised coordinates. In one case, the detection dog was able to locate a device that had been cached underground, likely by a fox, which would not have been recovered with human searching alone (Table 2; Supplementary Video 1).

Fig. 3 Examples of GPS field retrievals made by the detection dog. Habitat context (left) and GPS device in situ (right). Top row corresponds with Table 2 Retrieval 6. Bottom row corresponds with Table 2 Retrieval 4.

Table 2 Wildlife telemetry equipment retrieval attempts by a conservation detection dog and handler team

Retrieval	Date	Location	Tracked species	Habitat description	Outcome	Note
1	26/10/2021	Sutton, NSW	BSC	Dense Phalaris pasture.	Success	Only GPS present.
2*	13/01/2023	Forde, ACT	BSC	Grassy woodland, Rytidosperma tussocks.	Success	Only GPS present. Under tussock.
3*	13/01/2023	Forde, ACT	BSC	Dense Phalaris pasture.	Success	GPS on carcass.
4a*	09/02/2023	Mulligans Flat, ACT	BSC	Tall, dense mixed native grassland.	Fail	Incorrect search area.
4b*	28/02/2023	Mulligans Flat, ACT	BSC	Tall, dense mixed native grassland.	Success	Only GPS present.
5	29/05/2023	Mulligans Flat, ACT	BSC	Grassy woodland, sparse ground cover.	Success	GPS on carcass cached underground.
6	12/10/2023	Myall Lakes, NSW	SNI	Short pasture grass and scattered eucalypts.	Success	Only GPS present.
7a*	15/02/2024	Mulligans Flat, ACT	BSC	Short Themeda grassland.	Fail	Incorrect search area.
7b*	19/02/2024	Mulligans Flat, ACT	BSC	Short Themeda grassland.	Success	Only GPS present.

Alphanumeric code indicates individual GPS devices and attempts at retrieval (e.g., 4a and 4b are two attempts at one device). An asterisk indicates GPS devices where human-only searches were unsuccessful prior to the dog-handler team being deployed. Tracked species were bush stone-curlew (*Burhinus grallarius*; BSC) and straw-necked ibis (*Threskiornis spinicollis*; SNI)

Table 3 Controlled performance evaluation comparing detection dog to human-only searches (see Table 1 for definitions)

Type	Sensitivity	Precision	Mean effort [95% CI] min	Efficiency
Dog-handler team	100%	100%	6.4 [3.3–9.6]	15.52
Human-only	43%	100%	43.9 [33.3–54.4]	0.98

See Table 1 for definitions of sensitivity, precision and efficiency

Controlled performance evaluation

The dog-handler team located all targets in the presence trials (17/17), identified all true negatives during the absence trials (3/3), with no false positives or false negatives occurring (Table 3; Fig. 4A). The human-only searches (presence trials only) located 43% of targets (6/14) with no false positives (Table 3; Fig. 4A). The dog-handler team had an average search time of 6.4 min (± 1.5 SE, $n = 17$, 95% CI: 3.3–9.6 min). The human-only search time averaged 43.9 min (± 4.9 SE, $n = 14$, 95% CI: 33.3–54.4 min). The dog-handler team was significantly faster ($p < 0.001$; Fig. 4B) and 16 times more efficient (Table 3) than human-only searches. The slowest dog-handler search times (15, 19, and 20 min; Fig. 4B) occurred while the dog had lip fold dermatitis; this was resolved with antibiotic treatment. Temperature averaged 16 °C (range:

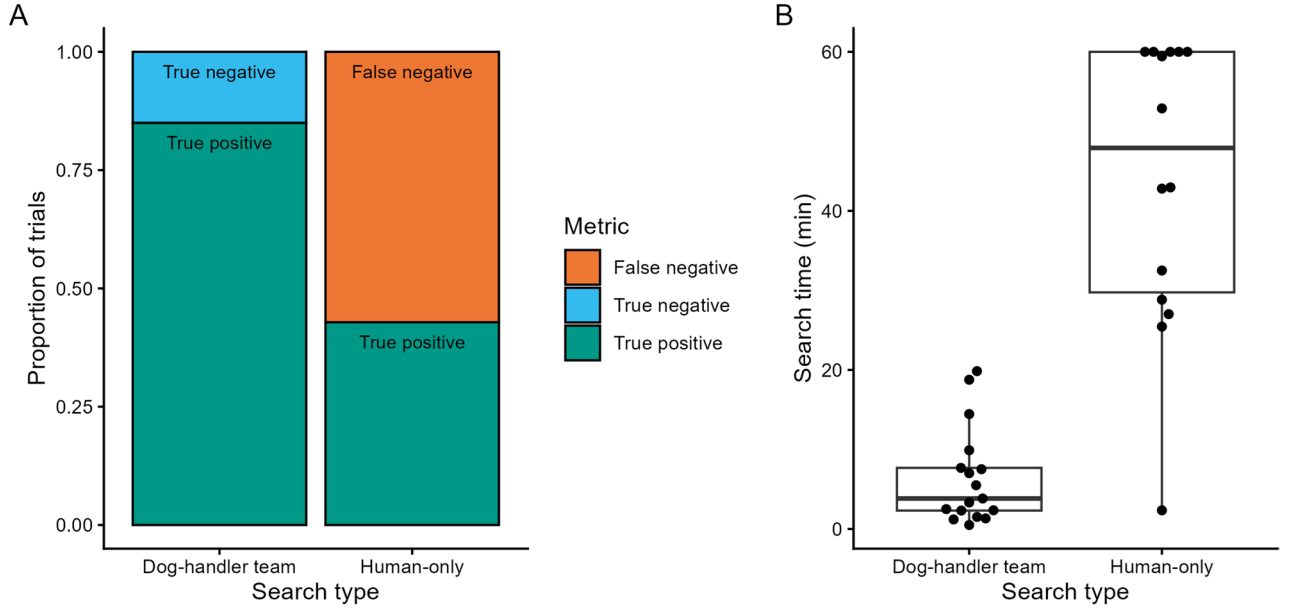

Fig. 4 Outcomes of a controlled performance evaluation. Comparison of a GPS detection dog and handler team (dog-handler team) with human-only searches. **A** proportion of true/false positive/negative results. **B** box-and-whisker-plot of search time during presence trials with raw data shown as points.

11–23 °C) and wind speed averaged 9 km/h (range: 0–24 km/h) during dog-handler team trials.

Discussion

Our study demonstrates that detection dogs can locate wildlife telemetry devices in the field. To our knowledge, this is the first reported use of detection dogs for this purpose. Under controlled performance evaluation conditions, the detection dog made no errors, and outperformed human-only searches that had a high rate of false negatives. Moreover, the detection dog was 16 times more efficient than human-only searching. Under real field conditions, the dog had a perfect retrieval record and was even able to locate a device that had been buried underground. Detection dogs can significantly improve device retrieval rates, with the associated benefits of additional data collection and increased device redeployment capabilities. Here we discuss detection dog performance, alternative approaches, and limitations to this study.

Performance

During field deployments, the dog-handler team successfully recovered all seven missing devices. In two cases, the team initially searched incorrect locations due to large GPS errors in the most recent fixes. Subsequent searches with corrected coordinates were successful, demonstrating that initial failures reflected challenges in defining search areas with low GPS accuracy rather than limitations in dog performance. Notably, the dog located one device that had been cached underground (Supplementary Video 1), which would not have been recovered through human searching alone. This capability is particularly valuable for wildlife tracking programs, as devices may become buried through predator caching (as occurred here), inundation in wetland environments, or gradual soil surface change. This aligns with the broader use of detection dogs for subsurface targets, such as human remains, landmines, and water leaks [49, 50], highlighting their ability to detect odours below ground.

During controlled performance evaluation, the detection dog achieved 100% sensitivity and precision. This performance exceeds or matches the upper range reported for other conservation detection dogs targets [sensitivity: 24–100%, precision: 27–100%, 17]. The dog-handler team outperformed human-only searches in the proportion of targets found (dog 100% vs. human 43%). Similar results have been documented for dog detection of Tasmanian masked owl (*Tyto novaehollandiae castanops*) pellets [dog 89% vs. human 40%; 22] and bilby (*Macrotis lagotis*) scats [dog 98.9% vs. human 6.7%; 51]. The 16-fold efficiency advantage we observed has significant practical implications for field operations. Staff time and associated costs allocated to retrieval of telemetry devices is an often underestimated major project cost [12]. Detection dogs can reduce this cost by increasing the rate of success while also reducing the time needed to undertake the retrieval.

No false positives were recorded from either the dog-handler or human-only searches. This was unsurprising, given GPS devices are easy for humans to visually confirm, compared to, for example, scats from similar-sized carnivores that are frequently misidentified [52, 53]. It is unlikely there were other objects with a similar odour profile in the landscape that could cause a discernment challenge for the dog. Moreover, detection dogs can have high rates of specificity even when discerning between similar targets, such as related species [39] or even scats from related species with identical diets [53]. Odour detection is somewhat a 'black box' process, where we often do not know precisely which odours or odour components the detection dog is targeting [18, 45, 54]. In this case, we suspect the combination of electronic components comprises the odour profile of the GPS device. We emphasise that the target odour in this study is the GPS device itself, and not the odour of the animal carrying the device. Training was initially conducted with GPS devices that had never been deployed and thus lacked animal odour. Furthermore, during the early stages of training, Koda gave an alert on a handheld gaming console, which comprises similar components to tracking devices (i.e., circuit board, electronics, plastic housing). While anecdotal, this provides further evidence that some combination of electronic components comprises the odour being targeted by the dog. Detection dogs have been used in law enforcement to detect other types of electronic devices, such as mass storage devices (e.g., hard drives, SIM cards), and these devices were demonstrated to have volatile odour components that could constitute a unique odour profile [55].

Considerations for implementation

While detection dogs offer substantial performance benefits, their cost-effectiveness and optimal implementation strategy depend on project-specific factors. Staff time invested in searching for lost devices represents a substantial yet often underestimated project cost [12] that detection dogs can significantly reduce. However, training or hiring a detection dog can also come at significant expense and therefore the relative benefit will vary on a project-by-project basis. Consequently, for projects with very few retrievals, human-only searches may be the most practical option despite reduced effectiveness, particularly if device costs are relatively low and some equipment loss is acceptable. However, device value is an important consideration: even a single retrieval of units costing thousands of dollars may justify the cost of investing in a detection dog.

There are two primary options for projects that elect to use detection dogs: training a dog "in-house" or collaborating with a professional detection dog team. Key considerations include expertise (professional teams bring proven experience in dog training/handling, search strategy and odour movement), timeframe (training an in-house dog requires months of preparation, whereas professional teams can often add new target odours to experienced dogs comparatively quickly), and cost structure (professional daily rates can be substantial, but may be less than the cumulative costs of acquiring, housing, and caring for an in-house dog plus the time investment in training and ongoing welfare management). This is, of course, not a comprehensive list of considerations. Projects with long timeframes, relevant expertise or mentorship, secure funding, and frequent deployment needs may benefit from in-house teams, whilst the majority of projects may find professional collaboration more effective and expedient. Alternative pathways include collaboration with detection dog teams from other backgrounds [e.g., a police dog trained to find primate scats; 38] and the emerging use of volunteer dog teams [see 56].

Alternative approaches

There are several alternative approaches to retrieve missing GPS tracking devices. We discuss these alternatives but argue that detection dogs remain the most efficient method. One option is to fit a VHF device alongside the GPS, so that the equipment can be found with a manual radiotracking receiver. However, this is not always practical from a cost perspective, nor viable from an animal ethics perspective, because the additional technology would increase the total weight borne by the animal. Additionally, VHF transmitter battery life may be substantially shorter than that of GPS devices [13]. Metal detectors offer another alternative, albeit an untested one. While this would overcome the limitations of visual-only searching, a detection dog would likely cover ground faster than a human-operated metal detector. Furthermore, metal detectors may produce high false positive rates in environments with metallic debris, particularly at the sensitivity settings required to detect small tracking devices. Future studies could compare metal detector performance with the detection dog metrics presented here. Finally, there are some emerging technologies that could be used to find lost devices, such as harmonic radar, which have ranges of approximately 125 m [57] and can detect electronics even when the battery is depleted [58]. However, these technologies are currently only able to detect the presence of devices and not pinpoint their location. In contrast, as put by DeGreeff et al. [55], detection dogs "are mobile detectors with integrated sampling systems that have the unique ability to use concentration gradient of the odor of interest to determine directionality, a feat no instrumental detector has been able to mimic" (p.1613). As such, we consider detection dogs to currently be the most efficient tool available to recover missing telemetry equipment.

An alternative detection dog approach is to target the animal's biological odour rather than the telemetry equipment itself. For example, detection dogs trained to find eastern box turtles (*Terrapene carolina carolina*) were used to locate turtles to both fit and retrieve VHF tracking equipment (L. Speight, personal communication, 2025). This approach may be beneficial if detection dogs are already trained on the target species (e.g., for population surveys). However, the drawback to this approach is that telemetry equipment cannot be recovered when separated from the target animal. Additionally, targeting the telemetry equipment instead of the animal provides flexibility to work on multiple tracking projects regardless of the species being tracked. Both approaches—targeting device odour or animal odour—demonstrate the versatility of detection dogs for wildlife telemetry applications and could be deployed strategically depending on project-specific needs.

Limitations

While controlled evaluations are considered best practice in assessing detection dog performance [40], there are several limitations that warrant discussion. First, this study evaluated only one dog-handler team. Performance on the same target may vary between individual dogs [18, 56], and also depends on the skill of the handler and the relationship between the dog and handler [17, 59–61]. Consequently, performance with a different dog or handler, or both, may differ from these results. Future projects could use the controlled performance evaluation methodology to characterise individual dog-handler team performance.

Second, we used a relatively small search area, and performance may not directly translate from one search area size to another [62, 63]. We selected the search area size because it was a reasonable proxy for field realistic conditions, while small enough that a time limit of one hour was reasonable, making volunteer participation feasible. Even in this small area, the human search volunteers reported search fatigue, where it became more difficult to keep searching effectively with elapsed time. Therefore, we predict that in a larger search area, human performance would likely decline further relative to detection dog performance.

Third, we tested under a narrow set of environmental conditions. During our study, temperature averaged 16 °C (range 11–23 °C) and wind speed averaged 9 km/h (range 0–24 km/h). While temperature, humidity and wind speed impact detection performance—due to changes in the behaviour of odour volatiles and their propagation in

the landscape [64] and changes in dog physiology such as panting [65]—there is no consensus in the literature on the direction and magnitude of these effects [17]. There does not appear to be a review documenting the effect of environmental conditions on detection dog performance, which would be a useful contribution to the field.

Fourth, we only used one brand of GPS device in this study. It is not yet known whether different types of devices vary in their detectability. However, anecdotal observations suggest that a detection dog can generalise between brands of similar GPS devices. In this study, the detection dog was trained on Ornitrack-20 devices and when first exposed to a different device, a GeoTrak-14 (a GPS-Argos satellite device manufactured by GeoTrak), she considered the odour for several seconds before giving an alert (Supplementary Video 2). Further testing of the ability of detection dogs to generalise between brands and types of telemetry devices is warranted. A detection dog trained on GPS devices may also be able to find other types of telemetry equipment (e.g. accelerometers). However, if finding a range of brands and types of telemetry devices was required for a project, this could be specifically included in the training protocol, rather than relying on generalisation. Generalisation varies with the temperament and training history of individual detection dogs, as well as the characteristics of the target odour [66–68].

Finally, we observed that a relatively mild veterinary issue had a notable adverse impact on detection performance. We recorded three slow dog-handler search times (15–20 min compared with an average of 4 min across all other searches), which coincided with the dog experiencing mild lip fold dermatitis. It was not initially apparent that these slower search times were unusual because they occurred towards the beginning of the study (the third to sixth trial), so we initially attributed this to a performance decline, which is known to occur during repetitive tasks [69]. Once we identified the dermatitis, we paused trials until it resolved with antibiotic treatment. Search times subsequently improved, suggesting even mild dermatitis may affect detection performance. The dermatitis may have altered air intake behaviour, potentially reducing odour intake or modifying air humidity and flow, all of which are important in olfaction [65]. While this report is anecdotal, veterinary issues are not usually included in reviews of factors affecting detection dog performance [e.g., 17, 18] and may warrant further examination. Nevertheless, even with these slower searches included, the dog-handler team remained significantly faster than human-only searches.

Conclusions

Detection dogs are highly versatile, with near limitless scope for the detection tasks they can perform [17]. Our study joins a growing number of projects using detection dogs to find non-biological odours in support of conservation programs [27]. We found detection dogs can locate GPS tracking devices (based on the odour of the device) and outperform humans at this task. The addition of a detection dog to our research team improved our efficiency in device recovery, with flow-on benefits including reduced project costs and improved data completeness. This novel approach has broad applicability for projects across diverse species and ecological contexts, and we particularly recommend this approach when visual searching is inadequate, such as in dense vegetation or when equipment may be buried underground. While we focussed on GPS devices, detection dogs could be used to locate various types of telemetry equipment. This approach offers a practical, efficient solution to equipment recovery challenges facing wildlife tracking programs worldwide.

Abbreviations

ACT	Australian Capital Territory
AUD	Australian dollars
BSC	Bush stone-curlew
CI	Confidence interval
GPS	Global positioning system
GPRS	General packet radio service
NSW	New South Wales
SE	Standard error
SD	Standard deviation
SIM	Subscriber Identity/Identification Module
SNI	Straw-necked ibis
VHF	Very high frequency
3G	Third generation (mobile technology)

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40317-026-00448-2.

Supplementary Video 1

Supplementary Video 2

Acknowledgements

We acknowledge and pay respect to the Ngunnawal, Ngambri, and Awabakal people, the traditional custodians of the lands on which this work was undertaken. This work was conducted within and with support from the Coexistence Conservation Laboratory (CCL) and in collaboration with the Wildlife Conservation Research Unit (WildCRU) at the University of Oxford. We thank Brittany Brockett, Steve Holiday, Marc Layton, Jenny Newport, Sean Rapley, Rachael Robb, and Maisie Walker-Stelling for their assistance. Particular thanks to Jenny Newport for assistance with the ethics protocol. The original idea to train dogs to find wildlife telemetry devices was conceived by Dr Heather McGinness, and we acknowledge the lessons learned from Heather's dog 'Rohan', the first dog trained to find wildlife telemetry devices in Australia. We are grateful for the valuable teaching in canine scent detection theory and practice that handler Heather McGinness and Rohan received from experts John Sam (Canberra Nosework Training) and Raelene Koerber (The Nose Knows). We also thank the Conservation Dog Alliance and the Australasian Conservation Dog Network, professional networks that provided support and guidance to Shoshana Rapley during the training and deployment of 'Koda'. We thank Koda for all her hard work on this project. We thank Laura Speight for sharing insights from the detection dog project locating turtles in Texas USA, which informed our discussion of alternative search methodologies. Finally, we thank the anonymous reviewers for their valuable feedback.

Author contributions
All authors contributed to project conceptualisation. HMG conceived the original idea to use detection dogs to find wildlife telemetry equipment. SR trained and handled the detection dog. SR, CS, HMG and MJV designed the performance evaluation. SR conducted the performance evaluation with support from MJV. SR conducted the analyses and wrote the manuscript. ADM, IJG, MJE, HMG and RH gave project supervision. ADM provided project administration. All authors read, commented on, and approved the manuscript.

Funding
The research presented in this manuscript received no funding. The GPS devices used in this study were reused from previous research, for which we are grateful to the Fenner School of Environment and Society at the Australian National University, BirdLife Australia's Stuart Leslie Grant and the 2019 NSW Twitchathon, and The Holsworth Wildlife Research Endowment & The Ecological Society of Australia for their funding support.

Data availability
The dataset generated and analysed during this study, along with the R script for analysis and Supplementary Videos 1 & 2, are available at https://github.com/coexistence-conservation-lab/telemetry-detection-dog.

Declarations

Ethical approval
Detection dogs are animal research subjects to whom we have a duty of care, as well as research team and family members. These protocols were approved by The Australian National University Animal Experimentation Ethics Committee (protocol A2022/14). 'Koda' is a privately owned companion animal whose care aligns with the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes [48].

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 30 September 2025 / Accepted: 23 January 2026
Published online: 08 February 2026

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