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Variable Vigilance: Native Wildlife React Differently to Live Cats and Their Cues

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ABSTRACT

Cats (*Felis catus*) kill millions of native Australian mammals and birds each year. The prey naivety hypothesis suggests this is due to native wildlife failing to recognise cats as predators. The Mata Hari Judas (MHJ) queen technique, where confined female cats are put into prolonged oestrus, has recently been trialled in situ as a method to attract and capture feral cats. This created the opportunity to observe how native wildlife respond to a live cat, or their olfactory and auditory cues, using camera trap detections before and after the introduction of a MHJ queen or its cues. Daily detection rates of eastern grey kangaroos, Australian magpies, noisy miners and northern brown bandicoots around the live cat did not differ between baseline and live cat periods, suggesting these species may not recognise live cats as a threat. However, red-necked wallabies and grey butcherbirds reduced activity in response to live cats or their cues. This study demonstrates that native Australian wildlife exhibit variable behavioural responses to cats and their cues. As predator control strategies evolve, integrating behavioural ecology into their design will be critical for their effectiveness, such as prioritising species that lack predator awareness.

1 | Introduction

Cats (*Felis catus*) continue to play a pivotal role in the high extinction rates and decline of Australia's native wildlife through predation, competition for resources and transmission of diseases (Legge et al. 2020). Of these threats, direct predation is thought to have a particularly strong impact on native species (Murphy et al. 2019), with cats estimated to kill at least 459 million native mammals (Murphy et al. 2019) and 377 million birds (Woinarski et al. 2017) each year in Australia. One explanation for this predator's success is the prey naivety hypothesis, which suggests that many native species fail to recognise cats as a threat and are therefore particularly vulnerable (Banks and Dickman 2007).

Numerous Australian studies have explored native wildlife responses to introduced predators, both in captivity (e.g., Blumstein et al. 2002; Edwards, Hoy, Fitzgibbon, Murray, and Goldingay 2024) and in situ (e.g., Saxon-Mills et al. 2018; Steindler and Letnic 2021; Edwards, Hoy, Fitzgibbon, Murray, and Cairns 2024). In situ studies typically use predator odour such as faeces or urine to determine responses by native wildlife, with more studies reporting a lack of recognition of cats (Edwards et al. 2021). While these studies aim to understand the behavioural and ecological impact of predators, such insights can also inform the development and refinement of predator control strategies. Given the well-documented impacts of cats on native wildlife, much effort has gone into developing and implementing cat eradication and control programmes.

These programs traditionally employ a combination of trapping, shooting and baiting, but can take years to complete, and remnant cats often prove difficult to remove (Algar et al. 2020). The 'Mata Hari Judas (MHJ) queen technique' (Murray et al. 2020) is a recently trialled cat control technique which uses female cats (queens) in prolonged oestrus and confined within enclosures in situ, to attract and capture feral cats (Dennien et al. 2024). The trial by Dennien et al. (2024) created an opportunity to observe how native wildlife responded to the presence of a live cat, or the olfactory and auditory cues of a cat, in situ. Therefore, we aimed to investigate whether native wildlife activity changed after the introduction of a live cat or its cues into the environment. Based on the literature surrounding prey naivety, and specifically native wildlife responses to cats, we hypothesised that camera trap detections of native wildlife would not change before and during the introduction of cat or its cues into the environment.

2 | Materials and Methods

2.1 | Study Area

The trial was conducted on three private properties in southeast Queensland, comprising primarily of Eucalypt woodlands and open forests. The properties are primarily used for conservation and ecotourism, although they were previously used for cattle grazing. Ad hoc predator control is undertaken on all properties.

2.2 | Mata Hari Judas Trial

Two identical custom enclosures measuring 1.5 m wide × 1.8 m long × 1.5 m high and constructed of aluminium sheets with wire mesh at the top of the walls were deployed at each property (see Dennien et al. 2024). One enclosure housed a MHJ queen induced into prolonged oestrus, and the other contained the MHJ queen's olfactory and auditory cues as a lure. A baseline monitoring period occurred for a minimum of 5 days to determine animal activity prior to the lures (a MHJ queen or the MHJ queen's olfactory and auditory cues) being placed in the enclosures (active period).

During the active period, urine and faeces from the MHJ queen were transferred daily to the cat cues enclosure. The vocalisations of a MHJ queen were recorded using an acoustic monitoring device (AudioMoth, Open Acoustic Devices) and replayed on a speaker (Megaboom 3, Ultimate Ears; maximum sound level 90 dBC) at the cat cues enclosures. The audio played a continuous cycle of vocalisations for 10 min followed by a 10-min break from approximately 5 pm to 6 am. The active period ranged from 11 to 15 days. For full details, see Dennien et al. (2024).

2.3 | Monitoring Wildlife Activity

The enclosures were monitored throughout the entire trial using camera traps (Swift Enduro, Outdoor Cameras Australia, Toowoomba, Queensland, Australia). At each enclosure, 12 camera traps were set facing the enclosure, varying in heights from 30 cm to 1.5 m to detect a range of wildlife. For full details on camera placement see Dennien et al. (2024). All cameras were set to take three consecutive images when triggered with no delay between triggers, on high sensitivity. Vegetation around all enclosures was cleared down to bare soil for approximately 1 m continuously around the enclosure and traps to improve visibility.

2.4 | Data Filtering and Analyses

To investigate whether native wildlife detections changed throughout the trial, the number of 'animal visits' was quantified for each species using camera trap data. As there were multiple cameras in close vicinity and directed at a similar area, animal visits incorporated data from multiple cameras as one visit. A visit was classed as separate if 5 min or more had elapsed between camera trap images of the same species (Meek et al. 2014), or unless an obviously different individual or an additional individual(s) appeared in the camera trap image. Images where the animal was not identified to species were removed. Images of cattle, humans and cats were also removed.

To examine the effect of the live cat or its cues on daily detection rates of wildlife species, we used generalised linear mixed models (GLMM) with a Poisson distribution. The response variable was the daily number of detections for each species with > 100 animal visits, with trial stage (baseline, cat/cues present) included as a fixed effect, while property was included as a random effect. For each species, we compared a full model (Model 1) including the trial stage as a fixed effect to a null model (Model 2) with only a random intercept for property, using the Akaike Information Criterion (AIC). The models were fitted using the glmer() function from the lme4 package (Bates et al. 2015) in R Studio (R Core Team 2021). Graphs were made using the ggplot2 package (Wickham 2016).

3 | Results

After initial filtering, there were 14 520 camera detections (resulting in 1826 animal visits from 29 species) at the live cat enclosures, and 10 226 camera detections (resulting in 1108 animal visits from 27 species) at the cat cue enclosures. The most commonly detected species were the eastern grey kangaroo (*Macropus giganteus*) (*N* = 575 visits), red-necked wallaby (*Notamacropus rufogriseus*) (*N* = 530 visits), Australian magpie (*Gymnorhina tibicen*) (*N* = 510 visits), noisy miner (*Manorina melanocephala*) (*N* = 496 visits), grey butcherbird (*Cracticus torquatus*) (*N* = 336 visits) and northern brown bandicoot (*Isoodon macrourus*) (*N* = 173 visits).

3.1 | Daily Detections in the Presence of a Live Cat

When a live cat was introduced in situ (the MHJ queen in the enclosure), there was no change in daily detection rates for all analysed species except red-necked wallabies (Table 1) (Figure 1). The daily detections of red-necked wallabies decreased when the live queen was placed in situ

TABLE 1 | Estimates (±SE), *z*-values and *p*-values for each species comparing animal visits between the baseline data (intercept) and the live cat or cat cues treatment.

Treatment	Common name	Estimate (±SE)	*z*-value	*p*
Live cat	Australian magpie	−0.13 (±0.12)	−1.263	0.207
	Northern brown bandicoot	−0.05 (±0.19)	−0.256	0.798
	Eastern grey kangaroo	0.02 (±0.09)	0.202	0.840
	Red-necked wallaby	−0.75 (±0.14)	−5.481	<0.001*
	Noisy miner	0.15 (±0.15)	1.010	0.313
Cat cues	Australian magpie	3.48 (±0.71)	4.889	<0.001*
	Grey butcherbird	−1.09 (±0.12)	−9.299	<0.001*
	Red-necked wallaby	−0.39 (±0.11)	−3.456	<0.001*

Note: Significant results are marked with an *.

($p < 0.001$) (Figure 1). For all live cat analyses, the full model was equal to or better than the null model (see Supporting Information S1–S3).

3.2 | Daily Detections in the Presence of Cat Cues

When cat auditory and olfactory cues were introduced in situ in the enclosures, there were significant changes in daily detection rates for all species analysed (Table 1) (Figure 2). The daily detections of red-necked wallabies and grey butcherbirds decreased when the cat cues were placed in situ ($p < 0.001$) (Figure 2). The daily detections for Australian magpies increased in the presence of cat cues in situ ($p < 0.001$) (Figure 2). For all cat cue analyses, the full model was better than the null model (see Supporting Information S1–S3).

4 | Discussion

Our results provide nuanced insights into how common native species respond to feral cats, with implications for both conservation and understanding predator–prey dynamics.

Consistent with the prey naivety hypothesis, most species showed no significant behavioural avoidance of a live cat in situ. The daily detection rates of the eastern grey kangaroo, Australian magpie, noisy miner and northern brown bandicoot did not differ between baseline and live cat periods, suggesting these species may not recognise live cats as a threat. Importantly, our study coincided with an increase in the number of feral cats detected on cameras at one property during the active live MHJ queen trial period (Dennien et al. 2024). This increase in free-ranging cats will likely have amplified predator cues across the landscape and increased local predator density, and so the lack of response of these species is worthy of further study. Furthermore, other species also in the area, but not included in analyses or detected on cameras, could have influenced wildlife activity.

However, red-necked wallabies significantly reduced their activity near the live cat and the cat cues. This suggests some level of threat perception or avoidance behaviour in this species. Wallabies, though falling outside the critical weight range most at risk of predation, may respond to generalised risk or stress associated with novel or threatening stimuli, and have been previously shown to respond to predator cues (Cox et al. 2014).

Interestingly, the introduction of cat olfactory and auditory cues led to broader and more significant behavioural changes than the presence of the live cat itself. Both red-necked wallabies and grey butcherbirds showed a decrease in daily detections, suggesting that indirect cues of predation risk may elicit a stronger or more widespread avoidance response than a confined, obscured live predator. These findings echo previous research indicating that predator odour and calls can significantly alter prey behaviour (Edwards et al. 2021; Steindler and Letnic 2021). This could also be explained by the fact that the cat vocalisations were played more frequently and potentially included more consistent or exaggerated vocalisations than those made naturally by live cats in situ.

In contrast, Australian magpies showed an increase in detections in response to cat cues. This may reflect investigative or mobbing behaviour, which has been observed in magpies and other passerines toward perceived threats (Kaplan 2011). Their increased presence may not indicate naivety, but rather a proactive, perhaps even territorial, behavioural response. This study is the first to report in situ behavioural responses of native Australian birds to feral cats. Despite the widely known impact of cats on avian fauna, there has been a surprising lack of empirical research documenting behavioural changes in birds. A global review by Anton et al. (2020) on prey naivety to exotic predators failed to identify a single study on Australian birds. Our results therefore make an important contribution to filling this gap and suggest that avian behavioural responses to cats may be more nuanced and species-specific than previously assumed.

While temporal overlap data between native species and cats would have offered valuable insight, the dataset was insufficient for this type of analysis. Future work should assess temporal avoidance patterns, which are increasingly recognised

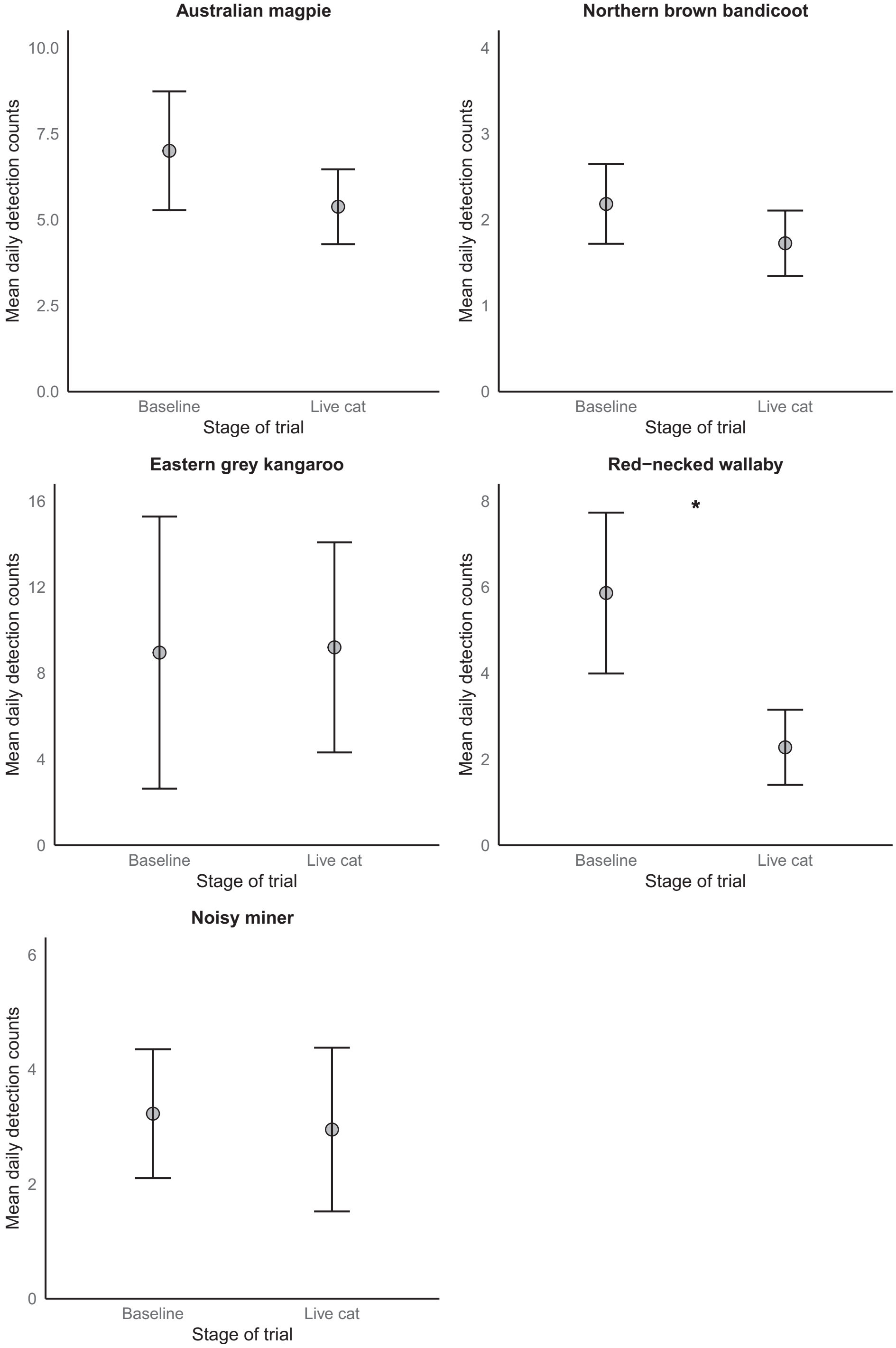

FIGURE 1 | Mean daily detection rates (±SE) of analysed species during the baseline period and in the presence of a live cat in situ. * Indicates a significant difference between the trial stages.

as important indicators of predator–prey dynamics. While our study provides valuable insight, there are limitations. First, the enclosed nature of the live cat trials may have reduced the perceived threat of the predator, limiting behavioural responses. Second, the short trial durations may not have captured longer-term changes in wildlife activity or habituation to the cues used.

This study demonstrates that native Australian wildlife species exhibit variable behavioural responses to introduced predators and their cues. While some species, like red-necked wallabies and grey butcherbirds, reduced activity in response to live cats or their cues, others showed no detectable change or even increased presence. These findings contribute to the growing body of evidence suggesting that prey naivety to cats is widespread but not uniform, and that indirect predator cues can strongly influence wildlife behaviour. As predator control strategies evolve, integrating behavioural ecology into their design will be critical for both effectiveness and reducing unintended consequences. Studying species-specific behaviours such as

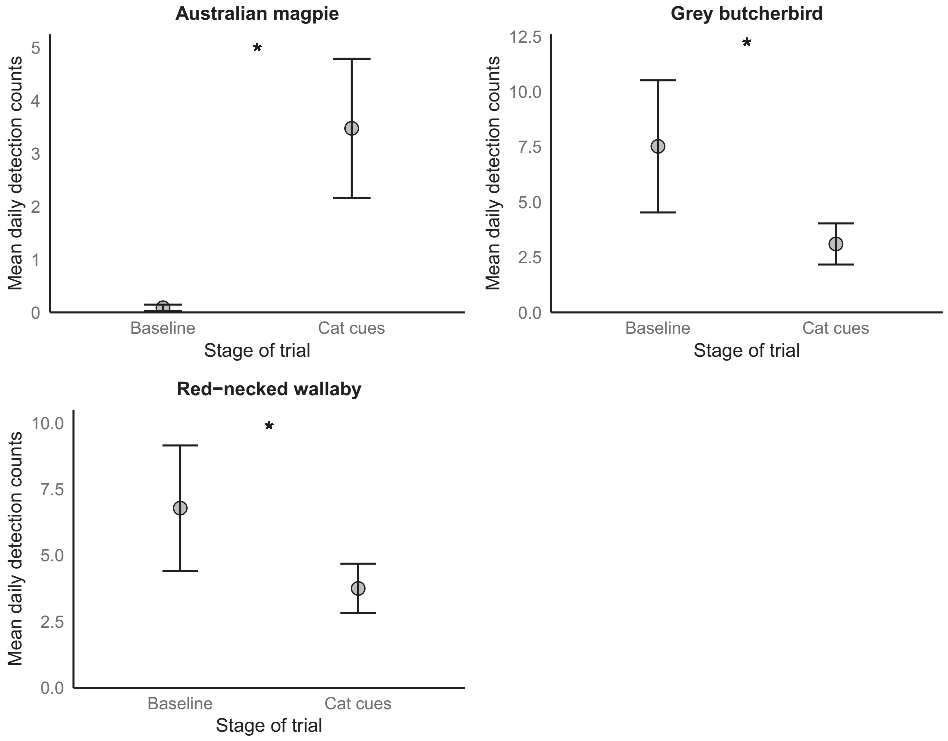

FIGURE 2 | Mean daily detection rates (±SE) of analysed species during the baseline period and in the presence of a cat auditory and olfactory cues in situ. * Indicates a significant difference between the trial stages.

predator avoidance helps managers to understand whether a species is likely to adapt over time, prioritise species that may need intervention due to a lack of predator awareness, and enhance the resilience of native populations. Failure to do so may leave Australia's native wildlife increasingly vulnerable to the devastating impacts of cats.

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Ethics Statement

This research was conducted under the University of Southern Queensland Animal Ethics Approval (21REA003) and ratified through The University of Queensland Animal Ethics Approval (2021/AE000707) and Restricted Matter Permit (Scientific Research; PRID000776). Thank you to the property managers and volunteers who provided assistance on this project.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that supports the findings of this study are available in the Supporting Information S1–S3 of this article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** aec0105-sup-0001-Supinfo1.xlsx. **Data S2:** aec0105-sup-0002-Supinfo2.xlsx. **Data S3:** aec0105-sup-0003-Supinfo3.docx.