

McComb Leo B., Lentini Pia E., Harley Dan K. P., Lumsden Lindy F., Antrobus Joanne S., Eyre Arabella C., Briscoe Natalie J. (2018) Feral cat predation on Leadbeater's possum (*Gymnobelideus leadbeateri*) and observations of arboreal hunting at nest boxes. *Australian Mammalogy* 41, 262-265.

DOI: <https://doi.org/10.1071/AM18010>

**Feral cat predation on Leadbeater's possum (*Gymnobelideus leadbeateri*)
and observations of arboreal hunting at nest boxes**

Leo B. McComb^A, Pia E. Lentini^A, Dan K. P. Harley^B, Lindy F. Lumsden^C, Joanne S.
Antrobus^D, Arabella C. Eyre^A and Natalie J. Briscoe^A

^A School of BioSciences, The University of Melbourne, Parkville, Victoria 3010, Australia

^B Wildlife Conservation & Science, Zoos Victoria, Healesville, Victoria 3777, Australia

^C Arthur Rylah Institute for Environmental Research, Department of Environment, Land,
Water and Planning, Heidelberg, Victoria 3084, Australia

^D Parks Victoria, Sherbrooke, Victoria 3789, Australia

Abstract

Feral cats have been identified as a major threat to Australian wildlife; however, their impacts on the critically endangered Leadbeater's possum (*Gymnobelideus leadbeateri*) are unknown. Here, we describe camera trap observations of a feral cat hunting at nest boxes occupied by Leadbeater's possum. Seven feral cats were subsequently captured within the surrounding area: two had Leadbeater's possum remains in their stomachs. The prevalence of cat predation on this species, particularly at nest boxes, and how this can be mitigated warrants further investigation.

Additional keywords: Arboreal mammal, *Felis catus*, predator, motion-activated camera, trail camera, invasive species, artificial hollow

Introduction

Introduced predators, including feral cats (*Felis catus*), are a major threat to Australian biodiversity and have had devastating effects on many native mammal populations (Woinarski *et al.* 2015; Doherty *et al.* 2017). Feral cats are generalist, opportunistic carnivores, and although arboreal mammals such as the common brushtail possum (*Trichosurus vulpecula*) and sugar glider (*Petaurus breviceps*) have been recorded in their diet (Molsher *et al.* 1999; Molsher *et al.* 2017), they are generally not dominant prey species (Doherty *et al.* 2015). It is unclear whether cats capture arboreal mammals in trees or when they descend to the ground, and whether hunting is concentrated around focal sites such as den locations. Feral cats have however been implicated in predation of some hollow-nesting birds (Saunders 1991).

Leadbeater's possum (*Gymnobelidius leadbeateri*) is a critically endangered, arboreal marsupial largely restricted to the Central Highlands east of Melbourne, Victoria. Key threats to the species include bushfire, timber harvesting and the loss of hollow-bearing trees (Lindenmayer *et al.* 2013; DEPI 2014). Predation by introduced mammalian predators (i.e. red foxes *Vulpes vulpes*, and cats) has not previously been considered a major threat to populations. Leadbeater's possums rarely forage on the ground where they might be more vulnerable to introduced mammalian predators (Harley 2016), but individuals have been trapped in Elliott traps set on the ground (Beilharz and Whisson 2015), observed denning in basal tree hollows (D. Harley pers. obs.; S. Smith pers. comm.), and occasionally sighted on the ground (L. Lumsden pers. obs., L. McBurney pers. comm.).

Nest boxes are widely-used to provide supplementary den sites for hollow-dependent fauna (Beyer and Goldingay 2006), including Leadbeater's possum (Harley 2016). Several papers discuss the benefits and limitations of providing nest boxes for Leadbeater's possum (Harley 2006; Lindenmayer *et al.* 2009), but none highlight elevated predation risk. European and North American studies have documented both increased rates of predation of birds using nest boxes (Sonerud 1985; Miller 2002) and also lower predation rates compared to natural nests (Huhta *et al.* 1998; Fargallo *et al.* 2001). In Australia, we are unaware of any published accounts of mammalian predators directing their hunting behaviour towards animals using nest boxes. Here, we provide evidence of a feral cat hunting at nest boxes occupied by Leadbeater's possum and confirm that feral cats prey upon the species in the local area.

Materials and methods

Nest box monitoring

Camera trapping was undertaken as part of a study investigating the microclimate of nest boxes provided for Leadbeater's possum in the Victorian Central Highlands. The nest boxes were constructed from recycled plastic, installed between 2009 and 2015, and positioned 3-4 m above the ground. Our monitoring targeted 47 nest boxes occupied by Leadbeater's possum across five study locations (Dowey Spur, Toorong plateau, Mt Baw Baw, Mt St Phillack, Mt Erica) in montane ash forest or sub-alpine woodland. Motion-heat activated camera traps (Reconyx Hyperfire HC600) were positioned 0.7-3 m from each nest box and facing the entrance holes to determine when possums were using the boxes. Cameras recorded five pictures per trigger at high sensitivity. Sampling occurred from June to October 2017, with 70-142 sampling nights per box. Resulting photos were examined to identify species present and their frequency of detection.

Cat trapping and stomach content analysis

Following the recording of camera images of a cat at the Dowey Spur boxes, cat trapping was undertaken at the site from 16 – 26 September 2017, commencing 24 days after monitoring ceased. Nine cage traps were set within 2.6 km of the nest box site. Traps were baited with tinned fish, meat scraps and dry cat food, and checked daily. Trapped cats were transported to Animal Aid in Coldstream, where they were deemed to be feral and euthanased in accordance with the Victorian *Domestic Animals Act 1994*. Stomach contents and scats were analysed using hair and bone identification.

Results and Discussion

Of the 47 nest boxes that were monitored with camera traps, two (15 m apart), were visited by a feral cat at the Dowey Spur site north-east of Powelltown. Distinctive markings on the cat suggest one individual was responsible for these visits. Each nest box was visited by this cat twice during the 70-day monitoring period, while occupied by the same Leadbeater's possum colony. There were two short (<7 min) daytime visits, and two longer evening visits (up to 64 mins) (Fig. 1). Evening visits coincided within 30 minutes of typical emergence time of the colony, which are highly consistent. On each visit, the cat climbed the tree, sat on the nest box lid, and inspected the entrance hole. During one evening visit, the cat was photographed unsuccessfully swiping at a Leadbeater's possum starting to emerge from the nest box (Fig. 1). This was the only occasion the cat and a Leadbeater's possum were

photographed in the same frame, and included 11 images collected over a 90-second period. There were no further photographs taken of the cat during the remaining 22 days of sampling. During this time the Leadbeater's possum colony, comprised of four individuals, continued to den in the two nest boxes visited by the cat (Fig. 1), shifting dens (back to their initial nest box) five days after the last observed cat visit. For the last 17 days of sampling only two individuals from the colony were observed, although detectability was likely influenced by a fallen limb that obscured the camera.

Subsequent cat trapping resulted in the capture of seven feral cats over 10 nights. Stomach and scat analysis revealed Leadbeater's possum hairs in two of these individuals (Supplementary material). These cats were both trapped within 500 m of the two nest boxes where the cat was photographed. An interval of 24 days between the end of camera trapping and commencement of cat trapping means although we didn't capture images of successful hunting by the cat, successful hunting at nest boxes cannot be discounted. Confirmation that feral cats are preying upon Leadbeater's possums raises several important questions, including: i) how are feral cats capturing Leadbeater's possum?; ii) how widespread and frequent is this behaviour?; and iii) is cat predation affecting the viability of local Leadbeater's possum populations? The latter should be considered in the context of other threats operating at sites (i.e. cumulative impacts).

It is conceivable that nest boxes are more conspicuous to predators than natural hollows. Increased predation rates on nest boxes over time suggest predators can identify nest boxes as a prey resource and develop long-term spatial memory or search images (Sonerud 1985; Miller 2002). The low heights at which Leadbeater's possum nest boxes are currently installed (3-4 m) may also facilitate cat hunting. However, cat hunting efficiency under such conditions is unknown. Nest boxes also provide a surface – the lid – on which cats can sit and wait for occupants to emerge (Fig. 1). Various types of predator guards to exclude rodents, weasels and snakes have been designed for bird nest boxes in North America, in some cases leading to increased nesting success (Bailey and Bonter 2017). Similar approaches could be investigated to restrict cat access to Leadbeater's possum nest boxes, potentially including placing collars around the lower trunks of trees or modifying the lid design. The extent of cat hunting at Leadbeater's possum nest boxes is currently unknown, with no further cats detected at an additional 63 nest boxes monitored over the summer of 2017/18.

Although feral cats are widespread across the Central Highlands (Robley and Fanson 2017), predation by feral cats has not previously been considered a major threat to Leadbeater's possum, and earlier studies in parts of this region did not detect Leadbeater's possum in cat or fox diets (Macfarlane 1988; Brown *et al.* 1989). Camera trapping has greatly increased detectability of cryptic species such as Leadbeater's possum (Harley *et al.* 2014; Nelson *et al.* 2017), and our study is the first to use cameras on a large scale over multiple locations to monitor Leadbeater's possum activity at nest boxes. Additional research is needed to quantify how predation may be influencing the viability of Leadbeater's possum populations, and in particular whether individuals using nest boxes face a higher risk of predation. This research should consider how predation risk for Leadbeater's possum varies with habitat quality. This is particularly relevant, given bushfires and timber harvesting have drastically altered vegetation structure in the Central Highlands (Burns *et al.* 2015), and introduced predators may target recently disturbed habitat for hunting (McGregor *et al.* 2016; Hradsky *et al.* 2017).

Acknowledgements

We thank the Arthur Rylah Institute, Department of Environment, Land, Water and Planning (DELWP) for the use of remote camera traps, without which we wouldn't have captured this sequence of events, and Zoos Victoria and the Mohammed Bin Zayad Species Conservation Fund for project funding. We are grateful to Ron Stielow from Feral Solutions for undertaking cat cage trapping, the cattery and vet clinic teams at Animal Aid Coldstream, Australian Wildlife Health Centre at Healesville Sanctuary and Robyn Carter for the hair identification. We also thank Tania Hoare, (DELWP) and Michael Kealy, Philip Rance, Shane Reger and Darren Barnes from Parks Victoria for their assistance in the transportation of cats. We thank Hugh McGregor and Matthew Rees for assistance with cat identification and Jemma Cripps, Louise Durkin and Jenny Nelson (Arthur Rylah Institute) for their advice and guidance during data collection. NJB was supported by the NESP Threatened Species Recovery Hub and PEL was supported by ARC Linkage Project (LP160100439).

Conflicts of interest

The authors have no conflict of interest.

References

- Bailey, R.L. and Bonter, D.N. (2017). Predator guards on nest boxes improve nesting success of birds. *Wildlife Society Bulletin* **41**, 434-441.
- Beilharz, L. and Whisson, D. (2015). Observations of ground activity in Leadbeater's possum *Gymnobelideus leadbeateri* in subalpine snowgum woodland at Mount Baw Baw, Victoria. *Victorian Naturalist* **132**, 21-22.
- Beyer, G.L. and Goldingay, R.L. (2006). The value of nest boxes in the research and management of Australian hollow-using arboreal marsupials. *Wildlife Research* **33**, 161-174.
- Brown, G.W., Earl, G.E., Griffiths, R.C., Horrocks, G.F. and Williams, E.M. (1989). Flora and fauna of the Acheron forest block, Central Highlands, Victoria. Ecological Survey Report No. 30, Department of Conservation, Forests and Lands, Melbourne.
- Burns, E.L., Lindenmayer, D.B., Stein, J., Blanchard, W., McBurney, L., Blair, D. and Banks, S.C. (2015). Ecosystem assessment of mountain ash forest in the Central Highlands of Victoria, south-eastern Australia. *Austral Ecology*, **40**, 386-399.
- DEPI (2014). Action Statement No. 62. Leadbeater's Possum *Gymnobelideus leadbeateri*. Flora and Fauna Guarantee Act 1988. Department of Environment and Primary Industries, Victoria.
- Doherty, T.S., Davis, R.A., van Etten, E.J.B., Algar, D.A., Collier, N., Dickman, C.R., Edwards, G., Masters, P., Palmer, R., and Robinson, S. (2015). A continental-scale analysis of feral cat diet in Australia. *Journal of Biogeography* **42**, 964-975.
- Doherty, T.S., Dickman, C.R., Johnson, C.N., Legge, S.M., Ritchie, E.G. and Woinarski, J.C.Z. (2017). Impacts and management of feral cats *Felis catus* in Australia. *Mammal Review* **47**, 83-97.
- Fargallo, J.A., Blanco, G., Potti, J. and Viñuela, J. (2001). Nestbox provisioning in a rural population of Eurasian Kestrels: breeding performance, nest predation and parasitism. *Bird Study* **48**, 236-244.
- Harley, D.K. (2006). A role for nest boxes in the conservation of Leadbeater's possum (*Gymnobelideus leadbeateri*). *Wildlife Research*, **33**, 385-395.
- Harley, D. (2016). An overview of actions to conserve Leadbeater's Possum (*Gymnobelideus leadbeateri*). *The Victorian Naturalist* **133**, 85-97.
- Harley, D.K., Holland, G.J., Hradsky, B.A.K. and Antrobus, J.S. (2014). The use of camera traps to detect arboreal mammals: lessons from targeted surveys for the cryptic Leadbeater's Possum *Gymnobelideus leadbeateri*. In 'Camera Trapping: Wildlife Management and Research'. (Eds P. Meek, P. Fleming, G. Ballard, P. Banks, A. Claridge, J. Sanderson, D. Swann) pp. 233-243. (CSIRO Publishing: Melbourne)

- Huhta, E., Jokimäki, J. and Helle, P. (1998). Predation on artificial nests in a forest dominated landscape—the effects of nest type, patch size and edge structure. *Ecography* **21**, 464-471.
- Hradsky, B.A., Mildwaters, C., Ritchie, E.G., Christie, F. and Di Stefano, J. (2017). Responses of invasive predators and native prey to a prescribed forest fire. *Journal of Mammalogy* **98**, 835-847.
- Lindenmayer, D., Blair, D., McBurney, L., Banks, S., Stein, J., Hobbs, R., Likens, G. and Franklin, J. (2013). Principles and practices for biodiversity conservation and restoration forestry: a 30 year case study on the Victorian montane ash forests and the critically endangered Leadbeater's Possum. *Australian Zoologist*, **36**, 441-460.
- Lindenmayer, D.B., Welsh, A., Donnelly, C., Crane, M., Michael, D., Macgregor, C., McBurney, L., Montague-Drake, R. and Gibbons, P. (2009). Are nest boxes a viable alternative source of cavities for hollow-dependent animals? Long-term monitoring of nest box occupancy, pest use and attrition. *Biological Conservation*, **142**, 33-42.
- Macfarlane, M.A. (1988). Mammal populations in mountain ash (*Eucalyptus regnans*) forests of various ages in the Central Highlands of Victoria. *Australian Forestry*, **51**, 14-27.
- McGregor, H.W., Legge, S., Jones, M.E. and Johnson, C.N. (2016). Extraterritorial hunting expeditions to intense fire scars by feral cats. *Scientific Reports* **6**, 22559.
- Miller, K.E. (2002). Nesting success of the Great Crested Flycatcher in nest boxes and in tree cavities: Are nest boxes safer from nest predation?. *The Wilson Bulletin*, **114**, 179-185.
- Molsher, R., Newsome, A. and Dickman, C. (1999). Feeding ecology and population dynamics of the feral cat (*Felis catus*) in relation to the availability of prey in central-eastern New South Wales. *Wildlife Research*, **26**, 593-607.
- Molsher, R., Newsome, A.E., Newsome, T.M. and Dickman, C.R. (2017). Mesopredator management: effects of red fox control on the abundance, diet and use of space by feral cats. *PloS one*, **12**, p.e0168460.
- Nelson, J.L., Durkin, L.K., Cripps, J.K., Scroggie, M.P., Bryant, D.B., Macak, P.V. and Lumsden, L.F. (2017). Targeted surveys to improve Leadbeater's Possum conservation. Arthur Rylah Institute for Environmental Research Technical Report Series No. 278. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
- Robley, A. and Fanson, B. (2017). Central Highlands Ark 2016 Biodiversity Monitoring Report. Unpublished client report for the Central Highland Ark Technical Working Group. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning.
- Saunders, D.A. (1991). The effect of land clearing on the ecology of Carnaby's Cockatoo and the inland Red-tailed Black-Cockatoo in the wheatbelt of Western Australia. *Acta XX Congressus Internationalis Ornithologici* **1**, 658-665.

- 282 Sonerud, G.A. (1985). Nest hole shift in Tengmalm's owl *Aegolius funereus* as defence
283 against nest predation involving long-term memory in the predator. *The Journal of Animal*
284 *Ecology*, **54**, 179-192.
- 285
- 286 Woinarski, J.C.Z, Burbidge, A.A. and Harrison, P.L. (2015). Ongoing unravelling of a
287 continental fauna: decline and extinction of Australian mammals since European
288 settlement. *Proceedings of the National Academy of Sciences* **112**, 4531-4540.



Fig 1. Timeline of the four cat visits to the nest boxes occupied by the same colony of Leadbeater’s possum during the sampling period in 2017. The two evening visits coincided with the time the colony typically emerged from the nest box, which was subsequently delayed by almost 2 h. (a) 12 July, 5.51-6.54 p.m., first visit by cat; (b) 31 July, 11.11-11.15 a.m., second visit (following this visit the possum colony shifted den location that night to the second nest box 15 m away); (c) 1 August, 11.33-11.40 p.m., third visit; (d) 1 August, 5.58-7.02 p.m., fourth visit.

Supplementary Material

Table S1. Prey contents identified from stomach and scat samples collected from seven feral cats caught during cage trapping.

Individual	Weight (kg)	Sample source	Prey contents
Cat 1 Tabby (male)	3.4	Stomach / intestinal tract	Agile antechinus <i>Antechinus agilis</i> Leadbeater's possum <i>Gymnobelideus leadbeateri</i>
Cat 2 Tabby (male)	2.95	Stomach / intestinal tract	Cat food (bait)
Cat 3 Tabby (female)	2.0	Stomach / intestinal tract	Swamp rat <i>Rattus lutreolus</i> Agile antechinus <i>Antechinus agilis</i>
Cat 4 Black (male)	3.4	Stomach / intestinal tract	Agile antechinus <i>Antechinus agilis</i>
Cat 5 Tabby (female)	3.75	No stomach contents	
Cat 6 Black (male)	2.04	Stomach / intestinal tract	Leadbeater's possum <i>Gymnobelideus leadbeateri</i>
Cat 7 Black (male)	4.0	Scat	Long-nosed bandicoot <i>Perameles nasuta</i> Agile antechinus <i>Antechinus agilis</i>