

## Thinking inside the box: Thermal suitability of artificial dens for hollow-dependent fauna

### In Brief

Many native species are dependent on tree hollows for nesting and denning. To address a shortage of tree hollows many conservation programs are installing nest boxes. One of the important characteristics of natural tree hollows is that they insulate animals from outside temperature extremes.

We investigated whether nest boxes and chainsaw-cut hollows also provide thermally suitable conditions for hollow dependent species. These studies, which targeted arboreal mammals, were undertaken in temperate forests in Victoria, which experience substantial seasonal variations in climate.

We found that maximum temperatures inside nest boxes were on average 8°C

hotter than inside natural hollows over summer and could put animals under physiological stress. The maximum temperature recorded in a nest box was 52°C compared to 38°C in a natural hollow. In winter, minimum nest box temperatures were significantly colder than in natural hollows.

These findings emphasise the importance of retaining natural tree hollows in large old trees as thermal refuges for hollow-dependent species in temperate south-east Australia.

Nest box colour and orientation had a large effect on internal temperatures, such that there was up to an 18°C difference in summer. Painting nest boxes light colours

and facing them south-east can help to protect animals from extreme temperatures in summer. Installing multiple nest boxes is important to provide animals with denning options under different climatic conditions.

Chainsaw hollows provided more stable temperatures than nest boxes across both seasons and show promise for providing environments that more closely mimic natural tree hollows.

During the study we observed cats utilising nest boxes for hunting. More research is required to quantify the threat and to investigate if different nest box designs could reduce this risk.

*Below: Temperatures were measured in nest boxes with different colours and orientation. Images: Steve Griffiths*





## Background

Many Australian animals, including mammals, birds and some reptiles use hollows for nesting and denning, and protection from predators and temperature extremes. Some species cannot persist without tree hollows or suitable substitutes (for example, they cannot breed without a suitable hollow), while others use them more opportunistically.

The significant loss of large, old hollow-bearing trees as a result of clearing for agriculture and urbanisation, as well as timber harvesting and bushfire, is a key threat to many hollow-

dependent species in Australia.

To offset this loss of natural hollows, conservation programs and urban wildlife projects often install nest boxes, including for Critically Endangered species such as the Leadbeater's possum.

We recently trialled a new approach for providing supplementary dens that involves cutting hollows into live trees using a chainsaw (termed 'chainsaw hollows').

Although artificial dens have been in widespread use for many decades,

research into the effectiveness of nest boxes and chainsaw hollows to supplement natural tree hollows is limited. One particular characteristic which is thought to have a significant influence on suitability, but which has been little investigated, is thermal conditions.

As climate extremes are predicted to intensify with climate change, this research set out to close some of the knowledge gaps about the thermal suitability and performance of artificial nest boxes and chainsaw hollows.

## What we looked at

In this research, we aimed to:

1. Evaluate the thermal suitability of nest boxes compared to natural tree hollows during seasonal extremes.
2. Investigate if thermal suitability can be improved by changing the colour or orientation of nest boxes.
3. Compare the thermal suitability of nest boxes and chainsaw hollows for the Critically Endangered Leadbeater's possum.

Our research was focused on temperate environments in south-eastern Australia, which experience substantial seasonal variations in climate.

## What we did

The team measured temperatures in wooden nest boxes suitable for brushtail possums and paired natural tree hollows in the Strathbogie Ranges of Victoria using small temperature data loggers, while also measuring ambient weather conditions.

We installed nest boxes at the same height and orientation, and under similar canopy cover as selected natural tree hollows.

To assess the thermal suitability for target arboreal mammal species, we modelled energy and water costs for animals using different types of hollows during temperature extremes using eco-physiological models.

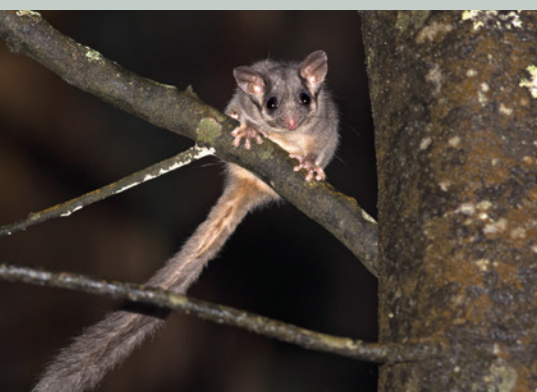
To investigate ways of improving nest box thermal performance, we measured the temperatures of bat and possum nest boxes painted in three different colours – white, light green and dark green – that were installed facing different aspects at sites around Melbourne.

We also measured the temperatures within nest boxes provided for Leadbeater's possums made from

recycled plastic that were installed across habitat types spanning an elevational gradient from 110 – 1580 m. At the same time, we monitored nest box and chainsaw hollow occupancy using camera traps.

In mountain ash forests, we compared the temperatures and humidity in artificial nest boxes with those in recently created chainsaw hollows. The chainsaw hollows were carved out by arborists, who cut directly into live trees using a chainsaw to make an internal cavity. These were then fitted with a door plate with an entrance hole specifically sized for the target species.

We also modelled the energy and water costs of Leadbeater's possum colonies using artificial dens across different habitats, accounting for the fact that the possums construct large nests of shredded bark that can provide additional buffering from temperature extremes.



*Right: Leadbeater's possums need hollows for breeding and denning. Image: T. Bawden*

## Key findings and their implications

Our key finding is that nest boxes provide less protection against temperature extremes than do natural tree hollows. In some habitats, nest boxes can reach extremely high temperatures under hot, sunny conditions, imposing high water demands and potentially heat stress on individuals using them during temperature extremes. Nest boxes were on average 8°C degrees hotter than natural hollows over summer, reaching a maximum temperature of 52°C, compared to the maximum of 38°C that we recorded in tree-hollows. In winter, nest boxes experience greater temperature fluctuations, reaching colder minimum temperatures and higher maximum temperatures.

In terms of our ability to manipulate nest box thermal performance, we found that nest box temperature is strongly affected by colour and aspect, as well as canopy cover (shade). White and light green nest boxes stay much cooler than dark green nest boxes during sunny periods, and south- and east-facing nest boxes are cooler than north- and west-facing nest boxes. For example, when ambient temperatures reached 31.3°C, west-facing dark-green bat boxes reached temperatures of up to 53.0°C (18.3°C and 18.9°C hotter than south-facing light-green and white boxes, respectively). Using lighter-

coloured nest boxes could better protect animals from temperature extremes during summer, particularly in open habitats that lack deep shade.

Another finding was that nest boxes used by Leadbeater's possums provided little protection against temperature fluctuations, with temperatures inside the nest boxes largely tracking ambient conditions. Temperatures recorded in the nest boxes ranged from -5°C in high-elevation snow gum woodlands in winter to 48°C in lowland habitats during summer. Modelling suggests that the insulative nests built by Leadbeater's possums could help protect them from cooler temperatures, but the possums may struggle to cope with extremely high nest box temperatures. Physiologically stressful high temperatures were rare except in lowland habitat, where temperatures above 40°C were recorded in 75% of lowland swamp forest boxes. We recorded few colonies using nest boxes over summer at this site with animals preferring to use natural tree hollows. The hottest occupied box temperature was 33°C.

Chainsaw hollows provided more stable temperatures than nest boxes across both seasons and show promise for providing environments that more closely mimic natural tree hollows.

## Observation of feral cats at nest boxes

Our research used camera traps to monitor animals using nest boxes. An unexpected observation caught by cameras at two nest boxes on several occasions was a feral cat sitting on top of the nest box waiting for animals to emerge.

Cat trapping was immediately conducted by Parks Victoria in this area. Seven feral cats were captured: two had Leadbeater's possum remains in their stomachs. Feral cats had not previously been considered a major threat to Leadbeater's possums.

There has been little research into predation risks at nest boxes in Australia, and how it compares to natural tree hollows. While our study did not set out to investigate whether some feral cats focus hunting activities around nest boxes, our observations indicate that more research in this area is warranted.

The provision of nest boxes for threatened species is an important conservation management strategy in many areas where natural tree hollow availability has been depleted. If it is established that the most commonly used 'box' styles of nest boxes increase cat predation rates, research into other shapes of nest boxes could be of value.

This research highlights that camera traps have the potential to provide novel insights on the occupancy patterns and behaviour of target species and predators at nest boxes.

*Right: During the study, camera traps detected a feral cat hunting at two nest boxes installed close together. The animal emerging in this photo is a Leadbeater's possum.*

*Image: Leo McComb*



## Cited material

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## Recommendations

Retaining large hollow-bearing trees that buffer animals against temperature extremes is vital, particularly as climate change is expected to increase the frequency and severity of extreme weather events.

To improve the success of programs that involve deploying artificial dens, managers should aim to provide animals with access to a range of artificial dens that collectively provide suitable thermal conditions across the different seasons. One way of achieving this is to vary the colour, orientation and shade profile of nest boxes.

Chainsaw hollows should be further investigated as a promising alternative to nest boxes. For Leadbeater's possums, chainsaw hollows may

be a useful tool for lowland populations, which experienced much higher summer temperatures than did the populations occurring at higher elevations. However, chainsaw hollows for this species require trees with large trunks, which are limited at this site, and the impact on trees should also be considered.

Finally, the observation of a feral cat hunting at two nest boxes used by Leadbeater's possums indicates that predator activity and impacts at nest boxes should be investigated further, and compared to rates at natural tree hollows. Nest box designs that may reduce this risk should also be explored.



Paired tree hollow and nest box in Strathbogie Ranges, Victoria, from study  
Image: Jessica Rowland

## Further Information

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