



Comparing the thermal suitability of nest-boxes and tree-hollows for the conservation-management of arboreal marsupials



Jessica A. Rowland ^{*}, Natalie J. Briscoe, Kathrine A. Handasyde

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

ARTICLE INFO

Article history:

Received 20 July 2016

Received in revised form 22 December 2016

Accepted 2 February 2017

Available online xxxx

Keywords:

Tree-hollow

Nest-box

Microclimate

Thermal habitat quality

Endotherms

Temperate zone

ABSTRACT

Hundreds of species rely on tree-hollows for shelter and breeding, however land-clearing has reduced their availability worldwide. While nest-boxes are deployed extensively in hollow-deficient habitats, their thermal value for arboreal marsupials compared to tree-hollows is unclear, particularly in temperate environments. We analysed thermal regimes in nest-box and tree-hollow pairs during summer and winter environmental conditions. Using a biophysical model, we quantified the relative suitability of den-sites for several marsupial species, estimating the impact of microclimates (and ambient conditions) on predicted heat-production and heat-loss. Nest-box temperatures were strongly influenced by ambient temperatures and solar radiation, whereas tree-hollows buffered external temperature fluctuations. On average, nest-boxes reached maximum temperatures 8 °C higher than tree-hollows in summer, and 3 °C higher in winter, with maximum temperatures of 52 °C recorded in nest-boxes, compared to 38 °C in tree-hollows. During summer, estimated heat-loss required by marsupials was 1.5–2.4 times higher in nest-boxes than tree-hollows. Conversely, predicted winter heat-production requirements were slightly lower in nest-boxes (0.95–0.97 of hollow requirements). Our study emphasises the importance of retaining tree-hollows as thermal refuges for hollow-dependent marsupials in temperate zones to reduce thermoregulatory costs during heat-events. Current nest-box designs are likely of limited value during high temperatures and solar radiation loads if they consistently reach temperatures exceeding species upper critical temperatures, however may provide suitable microclimates during winter. With increasing and more prolonged heat-events predicted under climate change, future conservation-management programs should focus on improving nest-box thermal properties to enhance suitability for wildlife.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Tree-hollows form essential habitat for hundreds of species worldwide, particularly birds and mammals (Goldingay, 2009; Goldingay, 2011; Scott et al., 1980). For many vertebrates, tree-hollows are critical for shelter, breeding and predator protection (Gibbons and Lindenmayer, 2002; Wesolowski, 2002), however, widespread land-clearing has dramatically reduced their availability (Eyre et al., 2010). Hollows large enough for arboreal mammals can take at least 100 years to develop (Gibbons et al., 2000; Wormington and Lamb, 1999). Ongoing habitat loss combined with time-lags in hollow-development, will likely maintain the deficit of tree-hollows (Gibbons et al., 2008; Vesik et al., 2008). This is of major concern for hollow-dependent species, as den availability and quality can impact survival, growth and reproduction (Catry et al., 2011; Dawson et al., 2005).

To compensate for tree-hollow loss, nest-boxes have been deployed by wildlife managers, individuals and community groups to support a range of hollow-dependent species (Beyer and Goldingay, 2006; Goldingay and Stevens, 2009; British Trust for Ornithology, 2016). Nest-boxes can be highly valuable for conservation (Durant et al., 2009; Goldingay et al., 2015). However, low occupancy (Lindenmayer et al., 2009) and suboptimal cavity temperatures (Catry et al., 2011) can limit their value. While there has been considerable research into how nest-box design and placement influence occupancy, surprisingly few data are available on the thermal suitability of nest-boxes, despite thermal properties likely being a key direct driver of their value for wildlife (Sedgely, 2001).

For endotherms, inappropriate den temperatures almost certainly have acute and long-term impacts, influencing survival during extreme conditions, and increasing costs associated with thermoregulation. Endotherms have an optimal range of environmental temperatures (thermo-neutral zone: TNZ) within which thermoregulatory costs are minimal (Lovegrove et al., 1991). Below their TNZ, metabolic heat-production (thus energy costs) increase, while above the TNZ, water costs rise because evaporative heat-loss is used to avoid overheating (Dawson, 1969). Hollow-dependent species can minimize

^{*} Corresponding author at: Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Burwood, 3125, Victoria, Australia.

E-mail addresses: jrowlan@deakin.edu.au (J.A. Rowland), nbriscoe@unimelb.edu.au (N.J. Briscoe), kathrine@unimelb.edu.au (K.A. Handasyde).

thermoregulatory costs by selecting dens providing temperatures closest to their TNZ.

Den microclimates influence breeding success and survival. Due to high thermoregulatory costs, animals experiencing unfavorable microclimates are likely to invest fewer resources in growth and reproduction (García-Navas et al., 2008). Tree swallow (*Tachycineta bicolor*) chicks in cooler nests have lower survival, slower growth rates, and smaller body size than those in warmer nests (Dawson et al., 2005). However, higher temperatures are not always beneficial: extreme den temperatures during a heat-wave led to 22% juvenile mortality in a lesser kestrel (*Falco naumanni*) population, with heat-related deaths occurring over two days when ambient temperatures exceeded 39 °C (Catry et al., 2011). Some evidence suggests that arboreal marsupials may avoid dens experiencing temperature extremes (Goldingay, 2015; Isaac et al., 2008a), which is almost certainly related to factors discussed above.

Despite the potentially high fitness consequences of denning in thermally sub-optimal microclimates, the thermal suitability of nest-boxes across seasons has not been comprehensively studied across the range of environments where they are deployed. The few previous studies suggest that thermal properties of empty nest-boxes and tree-hollows differ significantly, with tree-hollows buffering extremes in daily temperature fluctuations more than nest-boxes (Isaac et al., 2008b; McComb and Noble, 1981). However, Isaac et al. (2008b) only compared nest-box microclimates to tree-hollows during summer in a tropical climate, and McComb and Noble (1981) only compared microclimates in a few pairs of nest-boxes and tree-hollows across seasons in a humid subtropical climate. Minimal research has examined the thermal suitability of nest-boxes in temperate Australia, a region that experiences a wide temperature range, has undergone extensive habitat loss, and has had many nest-boxes installed (Harper et al., 2005; Lindenmayer et al., 2003).

Artificial and natural dens differ in structure, which is likely to drive differences in their thermal properties. Characteristics that influence nest-box temperatures include their insulative properties (relating to wall thickness and construction materials), orientation, and level of solar exposure (Charter et al., 2010; García-Navas et al., 2008; Goldingay, 2015). Temperatures in tree-hollows are also influenced by their structure (including wall thickness, cavity size and entrance area), in addition to tree health (Coombs et al., 2010; Paclík and Weidinger, 2007). Such differences in tree-hollow and nest-box properties may create disparities in their suitability for wildlife under different environmental conditions, between seasons or times of day (Vel'Ký et al., 2010). To maximise the success of nest-boxes for conservation it is essential to understand the drivers of variation in cavity temperatures.

While nest-box temperatures are likely to differ from those in tree-hollows, it is important to determine whether these translate to biologically meaningful differences in fitness for species using them. Few studies have examined the fitness consequences of denning in nest-boxes, and these focused predominantly on reproductive success in birds (e.g. Charter et al., 2010; Dawson et al., 2005), with little information about arboreal hollow-dependent mammals. Overall, studies of den microclimates rarely relate differences in temperature to eco-physiological consequences for species (although see Willis and Brigham, 2005; Willis and Brigham, 2007), important information for predicting and testing drivers of fitness.

We investigated how daily fluctuations in thermal microclimates differed between nest-boxes and tree-hollows across seasons in a temperate environment. We also examined factors influencing daytime den temperatures. We determined the relative thermal suitability of nest-boxes for four hollow-dependent marsupial species across seasons by estimating the energy and water costs of denning in nest-boxes, tree-hollows, or outside in a sheltered position, using a biophysical model that predicts how morphology, physiology and behaviour interact with the environment to determine animals' metabolic rate and rate of evaporative heat-loss (Porter and Kearney, 2009). Our research will inform management decisions regarding nest-box design and

installation, with a particular focus on understanding daily fluctuations in cavity temperature during extreme conditions.

2. Materials and methods

2.1. Study area and species

We conducted this research in the Strathbogie Ranges, (36°79' S, 145°80' E) Victoria, Australia (Fig. S1). The area has an average altitude of c. 570 m above sea level (a.s.l) and high annual rainfall (c. 1000 mm). It experiences considerable thermal variation, with temperatures exceeding 40 °C during summer and falling below 0 °C during winter. Temperatures range from a mean monthly maximum of 27.4 °C in February to a minimum of 1.7 °C in July (Bureau of Meteorology Climate Data, 2015).

This region has experienced substantial habitat loss and fragmentation (Martin and Handasyde, 2007), but retained some eucalypt-dominated open sclerophyll forest, which provides habitat for arboreal marsupials that rest in tree-hollows during the day. These include sugar gliders (*Petaurus breviceps*), common ringtail possums (*Pseudocheirus peregrinus*, henceforth common ringtail), greater gliders (*Petauroides volans*), common brushtail possums (*Trichosurus vulpecula*, common brushtail), and mountain brushtail possums (*Trichosurus cunninghami*, mountain brushtail) (Downes et al., 1997). Greater gliders and brushtail possums use a suite of tree-hollows solitarily (Harper, 2006; Lindenmayer et al., 2004; Martin, 2005), while common ringtails typically rest in small groups in dreys or tree-hollows (Pahl, 1987). Nest-box use has been recorded for common ringtails, both brushtail spp. (Harper et al., 2005; Lindenmayer et al., 2003) and sugar gliders (Menkhorst, 1984; Goldingay et al., 2015).

2.2. Comparison of den thermal microclimates

We compared daytime thermal microclimates of nest-boxes, tree-hollows, and ambient conditions during two summer periods (27/11/2014 to 3/01/2015 and 2–27/02/2015 between 06:00–20:30 h) and winter periods (29/06/2014 to 2/08/2014 and 7/06/2015 to 5/07/2015 between 07:30–17:30 h). Sampling periods within each season had similar environmental conditions (Fig. S2).

We selected 41 tree-hollows spread over 150 km² (Fig. S1), ranging from 481 to 674 m a.s.l. We considered tree-hollows suitable if the entrance and cavity were large enough to accommodate common ringtails (Beyer and Goldingay, 2006), <5.5 m high (for safety), and in live trees. Dead trees were excluded as their thermal properties may differ (Paclík and Weidinger, 2007; Wiebe, 2001). We used hollows in *Eucalyptus* trees with entrances opening on the trunk (n = 20) or tree-base (n = 21) to reflect the natural range used by wildlife (K. Handasyde unpublished data, based on radio-tracking data for brushtail spp.). We measured the entrance orientation (measured as °, converted into cardinal direction: north, n = 13; east, n = 13; south, n = 7; west, n = 8), entrance height above ground (to the nearest 5 mm), and DBH (mean ± sd: 1.3 ± 0.5 m). Hollows varied in structure: entrance area range 38.48–30,210 cm²; cavity depth range 18–140 cm; and cavity volume range 0.002–5.655 m³.

We installed 40 plywood nest-boxes (300 × 370 × 475 mm, 17 mm thick) between February and June 2014. One nest-box was relocated after the first two sampling periods (it was too dangerous to access) and paired with a different base-hollow for the remaining periods. Nest-boxes were painted dark-green, consistent with common practice. Each nest-box was mounted on a tree within 17 m (mean ± sd, 8.1 ± 2.7 m) of a tree-hollow, with the entrance at the same height and orientation, and similar canopy cover (mean difference ± sd, 5.8 ± 4.1%; $t_{39} = 1.36$, $P = 0.18$). We calculated canopy openness above each den by analyzing hemispherical photos, taken with a fisheye lens (Sigma 8 mm f6.3, Japan) attached to a full frame camera (Canon 5D MkII, Japan), using Gap Light Analyzer (Version 2.0) (Beckschäfer et al.,

Download English Version:

<https://daneshyari.com/en/article/5743338>

Download Persian Version:

<https://daneshyari.com/article/5743338>

[Daneshyari.com](https://daneshyari.com)