analyses, these trends suggest that the habitat value of plantings may be enhanced by including a large diversity of plants at establishment.

Previous studies have shown arboreal marsupials are uncommon in revegetation (Kavanagh *et al.* 2005; Cunningham *et al.* 2007) or regrowth forest (Kutt 1995), compared with remnant vegetation, but none of these studies considered the presence of old remnant trees. Most arboreal mammals require old trees with hollows for nesting (Gibbons & Lindenmayer 2002). We found that remnant trees were a valuable resource especially for the Common Ringtail Possum. Detection rates were also broadly similar in ecological plantings with old trees (3/9 sites) and remnants (4/18 sites) for the Common Brushtail Possum (Fig. 1).

Key ecological resources such as tree hollows and large logs can take decades to establish in revegetation, causing time-lags in habitat suitability for many species. This is of particular concern where plantings are used as offsets for vegetation clearing (Cunningham *et al.* 2007; Vesk *et al.* 2007). Our findings suggest that young plantings will have greater habitat value for several mammal species if old trees with hollows are incorporated into their design.

We conclude that many native mammals can use revegetation plantings, at least temporarily, and within only a few years of establishment. Use by mammals may be increased if plantings contain diverse plant species and old remnant trees.

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5.26

The use of temperature loggers to monitor tree hollow use by mammals. **Lisa Cawthen[1,2,3], Sarah Munks[1,2,3], Alastair Richardson[1,3] and Stewart C Nicol[1] ([1]School of Zoology, University of Tasmania, Private Bag 5, Hobart, Tas. 7001, Australia; Tel.: +61 3 6226 2613; Fax: +61 3 6226 2745; Email: lcawthen@gmail.com; [2]Tasmanian Forest Practices Authority, 30 Patrick Street, Hobart, Tas. 7001, Australia; [3]Cooperative Research Centre for Forestry, Private Bag 12, Hobart, Tas. 7001, Australia).**

Key words: *brushtail possum, forest management, temperature datalogger, tree hollow.*

Introduction

In Australia, tree hollows are a crucial resource for over 300 animal species. Recognizing the importance of maintaining tree hollows in the landscape, forest management agencies retain hollow-bearing trees for the conservation of hollow-dependent species (Wayne *et al.* 2006). Most guidelines for the retention of hollow-bearing trees in production forests are based on limited information and few studies have tested whether they are being used by fauna, such as hollow-using mammals.

Tree hollow occupation by mammals has been assessed by direct methods such as radio-telemetry, remote cameras and fibre optics (Lindenmayer *et al.* 1991; Purcell 1997; O'Brien & Kinnaird 2008) and indirect methods such as hair sampling (Gibbons *et al.* 2002). These methods successfully detect tree hollow occupation at a single point in time, but they are often unsuitable for long-term monitoring because they require personnel to undertake daily sampling. Developing a method that does not require daily sampling and is relatively inexpensive would benefit forest managers with limited resources.

As the presence of an animal in an enclosed space raises its internal temperature (Willis *et al.* 2005), monitoring hollow temperature should provide information on hollow use. Studies have used temperature dataloggers to monitor changes in roost temperature (e.g. Willis *et al.* 2005), but there is no published information on the application of temperature dataloggers for monitoring hollow use. This

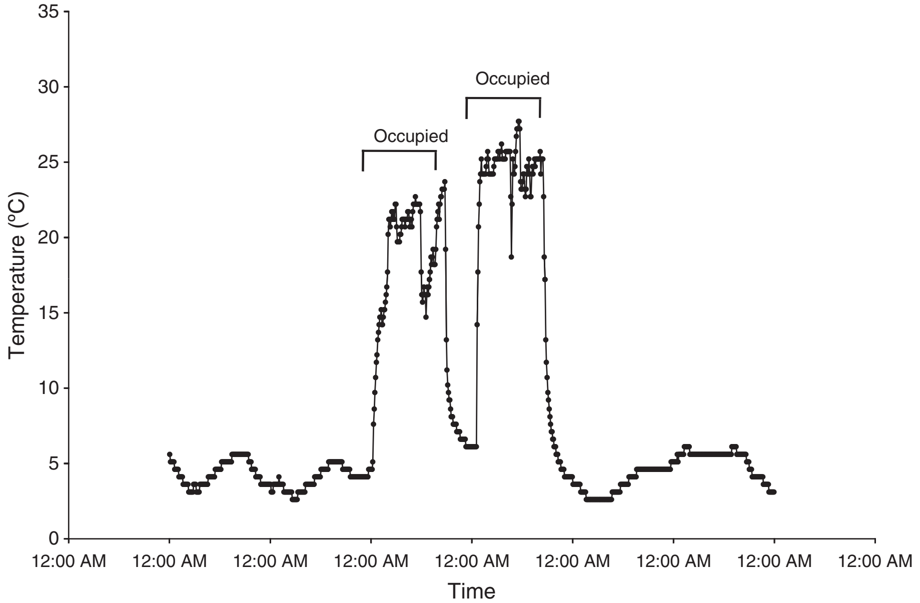

Figure 1. Daily temperatures within a tree hollow illustrating temperature rise while occupied by a radio-tracked brushtail possum.

paper presents a preliminary trial of temperature dataloggers as a means of detecting the use of hollows by the Tasmanian Common Brushtail Possum (*Trichosurus vulpecula fuliginosus*) (hereafter referred to as brushtail possum).

Methods

The study was conducted at two sites in State and private forest in south-east Tasmania. The first site was at Kellevie north-east of Hobart where a concurrent radiotelemetry study of den use by the brushtail possum was being undertaken (Cawthen 2007). The second was at Melton Mowbray in the southern Midlands of Tasmania. Five temperature dataloggers (17.35 × 5.59 mm) (Alfatek, iButton Model DS1922L/T; Dallas semiconductor, Dallas, TX, USA) (AUS $40 each) were placed in accessible tree hollows, between May and September 2007. Tree hollows were chosen based on their use by possums and their accessibility from the ground. Use of sampled hollows was verified by radiotelemetry at the Kellevie site during a concurrent radio telemetry study (Cawthen 2007). Use was not verified at the Melton Mowbray site, but hollows were selected for sampling based on wear around the hollow entrance, which indicated use (Gibbons & Lindenmayer 2002). Each logger was programmed by a laptop computer to record temperature at 10-min intervals for 56 days with a sensitivity of 0.1 °C. Each logger was fixed to a metal washer and attached to surgical cotton. This allowed the temperature logger to be lowered to the bottom of the hollow and tethered to the trunk or nearest branch. Once loggers were removed, data were downloaded to a computer using proprietary software (Mission Manager for Windows: Alfatek Australia, Bayswater, Victoria) for analysis.

Results

Temperature dataloggers successfully recorded temperatures for three of the five hollows (two at Kellevie, one at Melton Mowbray). Of the two hollows at Kellevie, only one was known to be occupied by a radio-tracked Brushtail Possum and showed significant changes in temperature from the daily averages. The other hollow showed no change. At Melton Mowbray, two of the three loggers were displaced from their hollows within the first 4 days of placement, presumably by hollow-using animals. The remaining logger did detect significant changes in temperature from the daily average; however, it is important to note that the use of this hollow by a possum was not verified by radiotelemetry but only by indirect signs (e.g. scratch marks) around the hollow entrance.

Relating patterns of temperature change in tree hollows to hollow occupancy by a brushtail possum

The temperature inside a tree hollow consistently increased when occupied by a Brushtail Possum. Although temperature inside an unoccupied hollow fluctuated slightly with daily changes in ambient temperature, the mean tree hollow temperature was relatively constant (6 ± 3 °C), while daily ambient temperatures varied from 0 to 22 °C in the area (Commonwealth of Australia, 2007 unpubl. data).

The presence of a brushtail possum produced an obvious effect on temperature readings, with an initial steep increase in temperature during the 10-min interval following occupation (Fig. 1). When occupied, the mean tree hollow temperature rose above mean unoccupied temperatures, with a recorded mean of 21 ± 4 °C, and a range from 8 to 28 °C compared with the mean 6 ± 3 °C. For the duration of the animal's occupancy, the temperature recordings remained high, allowing a clear differentiation between occupancy and non-occupancy. The temperature rapidly declined after the possum had left the hollow.

Monitoring the randomly selected hollows

Temperature peaks similar to those recorded in the hollow known to be occupied by a brushtail possum were recorded on 10 separate occasions in a hollow at Melton Mowbray. During temperature peaks (suspected occupancy by fauna), the tree hollow maintained a temperature above ambient temperatures with a recorded mean of 17 ± 6 °C and a range from 3 to 34 °C.

Discussion

Few methods exist that enable the monitoring of hollow use over time. Although researchers have used temperature dataloggers for some time to monitor tree hollow temperatures for biological studies (Ruczynski & Bogdanoweiz 2005; Willis *et al.* 2005; Paclik & Weidinger 2007), this method has not been used to monitor tree hollow use. Our results show that temperature changes inside a hollow during occupation can be accurately interpreted as occupation events. These changes may be in response to direct logger-animal contact, or the general rise in hollow temperature during occupation.

This trial was limited as two of the five loggers were removed from hollows. However, this problem could be minimized by deploying the loggers using wire, or nailing them inside hollows (Lisa Cawthen & Sarah Munks, 2008 unpubl. data). Although further work is required, temperature dataloggers have the potential to monitor the use of tree hollows retained as part of various conservation management options (e.g. isolated trees versus small patches). Unlike radiotelemetry, spotlighting or hair sampling, temperature dataloggers, once deployed, continually sample occupancy events of hollows until they are removed or the memory becomes full.

This method requires further refinement and extensive trials to determine how valuable it is for monitoring tree hollow use. This study deployed temperature dataloggers in accessible hollows from the ground relatively cheaply and required little time ($40 per logger + 2 days and associated costs for personnel and transport for deployment and retrieval of all loggers). However, most hollows are inaccessible from the ground, and how cost and time effective this method is when a tree climber must be employed is currently being investigated (Lisa Cawthen & Sarah Munks, 2008 unpubl. data). It also remains unclear what proportion of tree hollows can be sampled, as many trees (e.g. dead trees) cannot be climbed for safety reasons. It is also expected that some tree hollows (e.g. those with large exposed entrances) may have more variable internal temperatures, and consequently, deductions about animal use may not be as reliable as for those hollows that have enclosed entrances. It is also unknown what types of animals, other than brushtail possums, can be reliably detected using temperature dataloggers. It is possible that this method may return false negatives (i.e. animals may not always be detected) and this is something that needs to be determined with further work. Future controlled trials using other methods (e.g. remote cameras, hair tubes) need to be undertaken to determine how reliable this method is at detecting hollow use by mammals. Further refinement of this method will determine its limits and capabilities.

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