Author/s:
Briscoe, NJ

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Tree-hugging behavior beats the heat

Natalie J Briscoe*

National Environmental Research Program (NERP); School of Botany; University of Melbourne; Melbourne, Australia

Animals can exploit spatial and temporal variation in microclimates to avoid stressful conditions, behavior that is likely to become increasingly important in a warming world. Recent research shows that during hot weather cool tree trunk surfaces can provide an important heat-loss avenue for arboreal mammals and other tree-dwelling animals.

Animals can buffer themselves against the impact of climate extremes via their behavior.[1] As the climate warms, animals are likely to be exposed to thermally stressful environments more frequently. Yet while it has long been understood that via their behavior animals can 'fit the environment to their physiology',[2] we still have limited knowledge of how many species use behavior to buffer themselves against fluctuations in weather. Such knowledge is important not only for assessing species vulnerability to climate change[3] but for implementing management that enhances species resilience to future warming.

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*Correspondance to: Natalie J Briscoe; Email: nbriscoe@unimelb.edu.au

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Along with colleagues from The University of Melbourne, James Cook University and the University of Wisconsin, I recently investigated whether koalas use behavior to buffer themselves against climate extremes.[1] Koalas are arboreal mammals that inhabit Eucalyptus forests and woodlands of eastern Australia. Unlike most other arboreal marsupials in Australia they do not use dens for shelter, so are exposed to weather extremes. Koalas pant and may also salivate on their wrists or face to cool down at air temperatures above 30°C in the laboratory.[4] However, evaporative cooling may be costly in the wild when koalas have limited access to water, such as during the dry summer months in south-eastern Australia.

To test whether koalas in the wild circumvent the need for evaporative cooling via postural adjustments or microclimate selection, we radio-tracked koalas at a site in south-eastern Australia in both hot (air temperature > 30°C) and mild (air temperature < 25°C) weather, and recorded their behavior and the microclimatic conditions they experienced using a portable weather station mounted on an extendable pole. We also recorded microclimatic conditions at random locations within the study site to test whether the conditions experienced by koalas differed from those available. We expected that koalas would select more favorable microclimates during hot weather to minimise evaporative water loss. This was indeed true, with microclimates selected by koalas having lower solar radiation loads during hot but not mild weather.

That could have been the end of the story. But we also noticed that koalas altered their tree use during hot weather. Most puzzling was the fact that koalas used *Acacia mernsii* trees (a species they do not feed on) much more frequently during hot weather. They also sat on the main trunk of trees rather than out on lateral branches or the canopy, and moved closer to the ground as air temperatures increased. These microhabitats did not have lower solar radiation loads and meant koalas were further away from foliage that they eat.

When we measured the thermal profiles of trees, however, their behavior made perfect sense (**Fig. 1**). Tree surface temperatures were substantially cooler at the base and mid-trunk than lateral branches or the canopy, and the coolest trunks belonged to *Acacia mernsii* trees with mid-trunk temperatures that were on average 5°C cooler than air temperature. By hugging the trunk or large lower limbs of trees with their less densely furred belly pressed up against the tree surface, koalas enhance conductive heat loss (**Fig. 1**). Furthermore, models of heat exchange illustrate that this behavior could halve the amount of heat koalas need to lose via evaporative cooling over a typical hot day.

At high ambient temperatures, birds and mammals have limited avenues for heat loss and dumping large amounts of heat via evaporative cooling increases the risk of dehydration. When air temperature exceeds body temperature, tree hugging fulfils the dual function of facilitating conductive heat loss, while also reducing heat gained from the environment by minimizing the surface area over which convective and radiative heat gain occurs. Observations of birds in the desert[5] and flying foxes (J. Welbergen, pers com) suggest that cool tree trunks surfaces may be exploited by a wide range of species. The large temperature range observed within some individual trees (~10°C) also means that a single tree can provide a heterogeneous thermal landscape for small animals

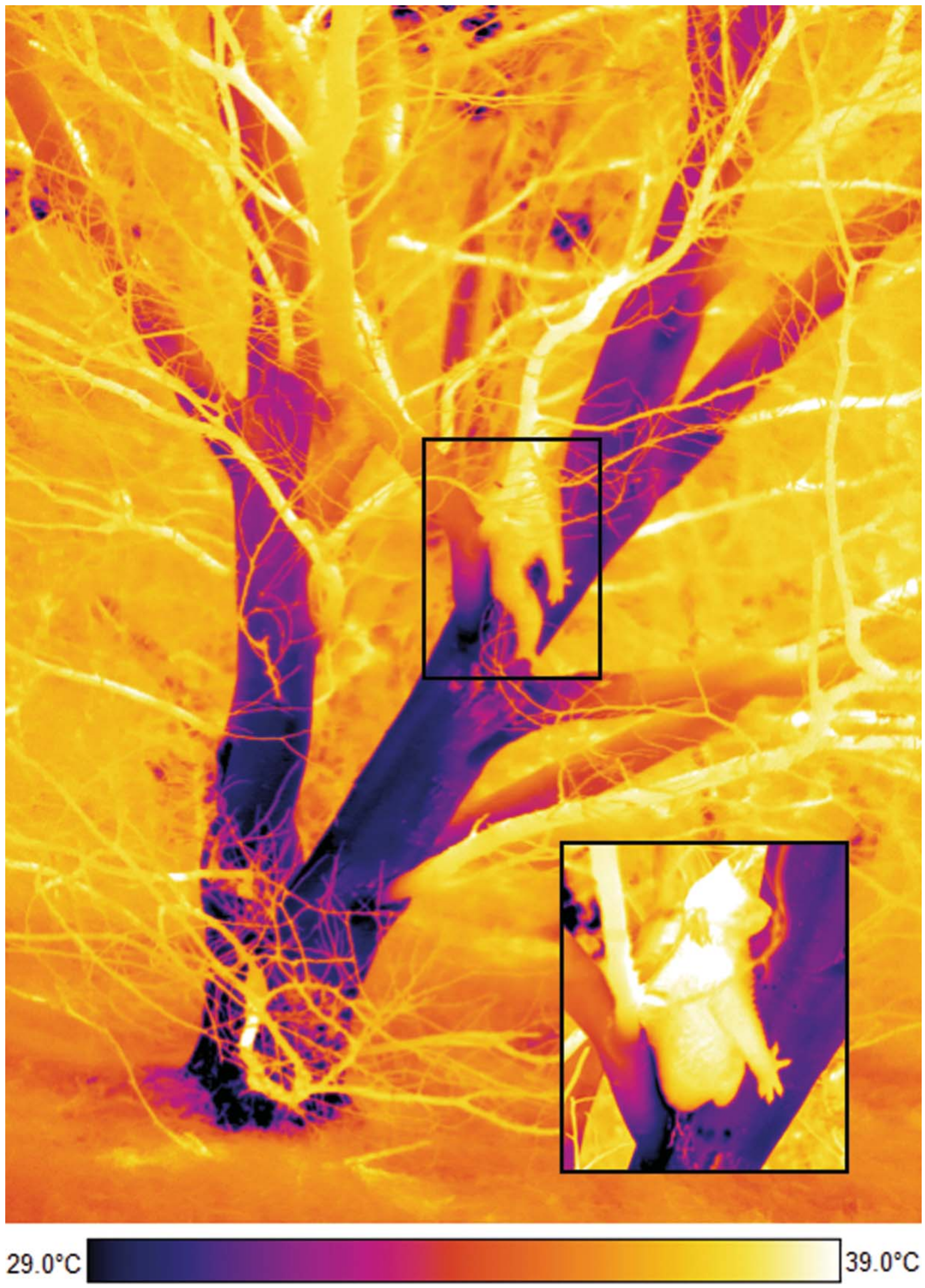

Figure 1. Thermal image of a koala hugging the cool lower trunk of an *Acacia mernsii* tree during hot weather; by resting against the coolest part of the tree koalas can reduce how much heat they need to lose by evaporative cooling (photo: Steve Griffiths, reproduced from[1]).

such as lizards or insects, in hot as well as cold environments.[6]

While unravelling the processes driving trunk surface temperatures was outside the scope of our study, such an understanding would grant important insight into where and when these microhabitats are likely to be important. At our study site tree trunks were relatively protected from direct solar radiation, which can drive large temperature gradients, particularly during cold weather.[6] In addition, large daily and seasonal temperature fluctuations in south-eastern Australia mean that during hot summer weather ground water drawn up through the trunk due to transpiration is likely to be substantially cooler than maximum air temperatures, and cool night-time temperatures mean that large tree trunks or branches may remain cool due to thermal inertia. Notably, we found that thermal profiles differed between the four tree species we measured, suggesting species traits, such as bark properties and root depth, are also important.

Studies of thermoregulatory behavior provide important insight into how animals use their environment. While high quality koala habitat has typically been defined by the presence of preferred food trees, it is now evident that thermoregulatory requirements also drive habitat use.[1,7] Ensuring that koalas have access to trees that provide deep shade and cool trunk surfaces is a relatively straight-forward management option that could enhance koala resilience to hot, dry conditions. Given that many other arboreal species are likely to exploit cool tree trunks as heat sinks during hot weather; these microclimates deserve further attention in our efforts to manage biodiversity under climate change.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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