Science for Saving Species

Research findings factsheet

Project 3.2.3.2

Threatened Species Recovery Hub

National Environmental Science Programme

Improved biodiversity monitoring with thermal cameras

In brief

Effective conservation of a species is difficult without a clear picture of the population and where it is present. Arboreal mammals are often hard to detect with traditional techniques, and this can have consequences for their conservation. For example, the true conservation status of Lumholtz's tree-kangaroo (*Dendrolagus lumholtzi*) is uncertain due to low detectability by standard survey techniques.

We aimed to improve methods for monitoring Lumholtz's tree-kangaroo, which is found in rainforests of Queensland's Atherton Tableland Region. We surveyed rainforests in north Queensland using daytime surveys, night-time spotlighting and thermal imaging to compare detection rates of animals by these methods. We also conducted a similar small-scale survey testing these methods for small mammals in a semi-arid environment.

Both studies showed that thermal imagers were more efficient and effective at detecting the target animals than spotlighting. We found thermal imaging technology to be reliable and cost-effective. Handheld thermal imagers continue to decrease in cost, and they are now a viable option for monitoring animals, including species that are difficult to detect in complex habitats, such as dense forest canopy. Incorporating thermal technology into monitoring surveys will greatly increase detection probability for Lumholtz's tree-kangaroo. This information can improve the conservation outlook for the tree-kangaroo, as well as for many other hard-to-detect species.

Background

Monitoring threatened species and management effectiveness is constrained for many species by difficulties in detecting them. Many animals are cryptic by nature and are difficult to detect and monitor effectively by traditional monitoring methods. To exacerbate the situation, a large part of Australia's mammalian fauna is nocturnal. Traditional techniques for monitoring wildlife are often very expensive, inefficient and sometimes even logistically impossible.

Ever-improving technology is reshaping the way researchers think about biological surveys. Improvements to monitoring using new technologies, such as drones and thermal cameras, can be achieved in several ways, by: increasing detectability for a given effort; improving the precision of counts; reducing false positive observations; collecting more data within a given survey time; allowing access to remote sites; or covering a greater area than is feasible with more traditional techniques.

The cost of thermal imaging technology has recently decreased to the point that it can be considered as a feasible monitoring tool for wildlife surveys. Thermal imaging cameras detect warm-blooded animals due to their radiation of body heat, enabling this technology to detect animals not easily visible to the naked eye. Thermal cameras have the potential to increase the accuracy and statistical power of wildlife monitoring surveys, especially for night surveys of nocturnal species.

Thermal cameras, however, are an emerging technology and little is known about how useful they are across the full range of Australian species and habitats. Nonetheless, they have already been used in some circumstances to great effect. Unlike motion detection cameras, thermal imaging cameras allow researchers to estimate the density of animals across the landscape.

THE UNIVERSITY OF MELBOURNE
UNIVERSITY of TASMANIA
JAMES COOK UNIVERSITY AUSTRALIA

Research aims

We aimed to compare the cost-effectiveness of traditional survey methods and thermal imaging methods for surveying a cryptic arboreal mammal, Lumholtz's tree-kangaroo (*Dendrolagus lumholtzi*) in dense rainforest in far north Queensland.

We also aimed to compare the performance of spotlighting to use of a handheld thermal camera to detect threatened mammals in a semi-arid environment in the critical weight-range of 55 g to 3 kg.

Young Lumholtz's tree-kangaroo. Image: L. Valentine

What we did

Lumholtz's tree-kangaroo

This study took place on the Atherton Tablelands in north Queensland. We surveyed ten sites for Lumholtz's tree-kangaroo in 2016, including five transects along edges of fragments (edge sites) and five transects on tracks within forest patches (interior sites). Six of the sites were further surveyed in 2017. We conducted daytime surveys, spotlight surveys at night, and spotlight surveys at night with the addition of a handheld thermal imager ("thermal surveys").

We performed spotlight surveys using a headlamp to allow animal eye-shine detection. Thermal surveys used a handheld thermal scope (Pulsar Quantum XD19S). Headlamps were still required to positively identify the species after a thermal detection. We modelled the detectability of the tree-kangaroo statistically, using survey data from the different survey types.

We carried out a cost-effectiveness analysis to compare the return from each method for given budgets at sites where the occupancy of the tree-kangaroo was unknown. For each method, we calculated the number of repeat survey visits required per site to be 95% confident that the species would be detected if present. Time cost was defined as $30/hr and the equipment costs were $290 for spotlight surveys (cost of two LED Lenser H7R.2 headlamps) and $3940 for the thermal surveys (one Quantum Pulsar XD19S thermal scope plus two LED Lenser H7R.2 headlamps).

Semi-arid zone study

In March 2020, we conducted a small pilot study in the semi-arid environment of Scotia Wildlife Sanctuary, a private reserve in western New South Wales. We carried out surveys using either a spotlight or handheld thermal camera to detect the bridled nailtail wallaby, the greater bilby, the burrowing bettong and the rufous hare-wallaby. Surveys were carried out with equipment fitted to a car. We used a distance sampling model to analyse and compare our findings.

Key findings

Lumholtz's tree-kangaroo

Thermal surveys gave a greater chance of detecting the tree kangaroo than did either daytime or spotlight surveys. The estimated detectability at interior sites when the average air temperature is 18.6°C was extremely low using day surveys, at 0.20% probability of detection. The chance of detecting a tree kangaroo was higher with night time spotlight surveys, at 2.5%, but was the highest by far for thermal surveys, at 27.7%.

At the edge sites, these values increased to 17.2% for day surveys, 72.1% for spotlight surveys and 97.5% for thermal surveys. We believe that detectability at edge sites was higher because the line of sight to animals was less obscured by vegetation and observers can move more freely to advantageous observing positions. Previous research suggests that tree-kangaroos do not prefer the edges of forest fragments.

The best-fitting model to determine the probability of detecting a tree-kangaroo included the factors survey method, site type, air temperature and soil type. Estimated detectability increased with temperature, which may be due to the tree-kangaroo's behaviour, with anecdotal accounts of individuals often found lower in the canopy when temperatures are high. Several other models explained the data almost as well, indicating that other factors could be important in determining the detectability of an animal on any given survey night.

LEFT: Thermal image of a Lumholtz's tree-kangaroo, as viewed through the Pulsar Quantum XD19S scope, captured using a smartphone camera. Image: Chris Pocknee

Key findings (continued)

The day surveys had low success as these animals are mostly active at night when they move to lower branches to forage. The thermal hotspot from one of these mammals is bigger than its eye-shine when spotlighting, due to the contrast with the cooler surrounding environment. This aids detection using thermal methods. Detecting eye-shine also relies on the target animal facing the observer.

Fog had no significant impact on detectability, and would not be expected to be an issue in future surveys unless they were carried out in fog that was extremely dense.

Cost-efficiency

Day surveys could not be recommended under any budget situation, due to the low chance of detecting a tree-kangaroo. When equipment is already available, thermal surveys are clearly the most cost-effective technique, due to their higher detection probability.

With time costs only, thermal surveys returned a cost of $133.67 to achieve a 95% probability of detecting the species if present at a site, compared with $187.06 for spotlight surveys and $797.34 for day surveys.

When equipment needs to be purchased, spotlight surveys would be the preferred method up to a budget of $13,078.29. At any budget above $13,078.29, thermal imaging surveys could allow the occupancy status of tree kangaroo to be determined at a greater number of sites than spotlight surveys for the same amount of time. (See Figure 1.)

Semi-arid zone small mammal study

We saw a large increase in detection probability when using the handheld thermal camera to monitor small mammals compared to using the spotlight. The flat and open landscape at Scotia Wildlife Sanctuary enabled the thermal camera to detect animals up to 55 m away, whereas spotlighting failed to detect animals beyond 25 m.

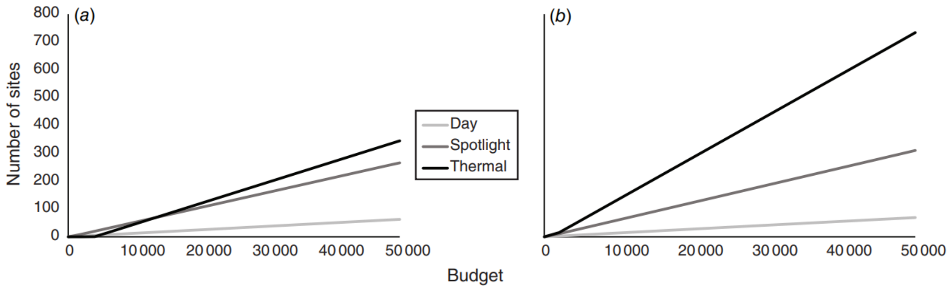

Figure 1. Comparison of the expected number of sites at which Lumholtz's tree-kangaroo occupancy could be determined with 95% confidence (false negative rate 5%) between three survey methods with increasing budget, where equipment needs to be purchased (a) and where it is already available (b).

Implications and recommendations

Our results support the use of thermal imaging for detecting tree-kangaroos, a cryptic, mid-sized arboreal mammal, in rainforest and for detecting small mammals in the critical weight range in a semi-arid landscape. These represent two extremes of vegetation type, and our findings indicate that thermal imaging is likely to be applicable in other habitats such as forests and woodlands.

A key benefit of using the handheld thermal camera is that detection does not rely on an animal's eye-shine, unlike spotlighting. Our studies provide evidence that thermal imaging technology can be effective for monitoring some of Australia's rare and cryptic threatened mammals, aiding their conservation.

Thermal imaging devices vary greatly in cost, with basic units usually priced upwards of $800 (e.g., FLIR Scout TK Thermal Vision Monocular) and more advanced equipment over $14,000 (e.g., FLIR T530Thermal Imaging Camera), although costs keep decreasing. The two major differences between high-end and low-end models are resolution and whether the model is radiometric. Radiometric units provide absolute temperature values, and are generally more expensive than non-radiometric models, which only measure relative temperatures.

Many wildlife monitoring programs are focused on identifying habitat where a species is present. If the objective of a survey is to just detect the presence of a species at a site, our results show that thermal imaging may increase cost-efficiency by decreasing the time required to detect target species.

To better understand the role of vegetation type and density on detectability, future surveys

LEFT: Rainforest, Atherton Tablelands, Queensland.
Image: Owen Allen, Flickr, CC BY 2.0

Implications and recommendations (continued)

should be undertaken across a range of environments. For some species and circumstances, it may be desirable to compare the effectiveness of this technology with indirect methods such as camera-trapping. Knowledge of the species' ecology and the strengths of various survey techniques may guide researchers as to whether to compare thermal imaging to other methods or potentially use it for monitoring surveys without requiring further assessment.

Drones and biodiversity monitoring

Unmanned aerial vehicles, or drones, fitted with thermal imaging cameras have the potential to improve data collection for biodiversity monitoring. They could be useful in situations where other survey techniques are impractical, such as in rough or remote terrain. We tested the method using a drone (DJI Phantom 3 quadcopter multirotor UAV) fitted with a thermal camera to monitor small mammals in semi-arid vegetation in western New South Wales.

Unfortunately, due to practical issues, the aerial thermal surveys using the drone produced few definite mammal detections, so we couldn't compare the results with other survey method in statistical terms. Battery time restricted the range and area that could be covered during a single flight.

Drones are also subject to restrictions by governing bodies and can only be flown for research purposes by an authorised individual holding a remote pilot license. The drone must always be visible to the pilot and cannot be flown in fog. Strong winds also hindered our flights, and we needed to apply for additional permits to carry out surveys at night. Due to these limitations, we did not find drones a practical tool to increase the detection efficacy compared to the handheld thermal cameras in this woodland and shrub habitat.

Drones with various sensors and/or cameras attached may, however, be suited to other conditions where there are few obstacles (e.g., grasslands) and for which an aerial view would provide a better ability to detect individuals than would views from the ground. For example, drones have been successfully used as a low-cost approach to determine sea turtle density and observe sea turtle behaviour from a distance without human disturbance. In circumstances where aerial views are of great value, drones may represent a more economical survey method than helicopters or aeroplanes. Drones have also been successfully used to observe crocodile and bird nesting, to determine the density of mangrove trees and to collect water samples.

Works cited

Christopher A. Pocknee, José J. Lahoz-Monfort, Roger W. Martin and Brendan A. Wintle (2021) Cost-effectiveness of thermal imaging for monitoring a cryptic arboreal mammal. *Wildlife Research*. https://doi.org/10.1071/WR20120

Asitha Pramudith Samarawickrama (2020) Are thermal cameras more effective than traditional spotlighting methods for detecting critical weight range threatened mammals in a semi-arid environment? Honours thesis, University of Melbourne.

Jesús Jiménez López and Margarita Mulero-Pázmány (2019) Drones for conservation in protected areas: present and future. *Drones* doi:10.3390/drones3010010

Gail Schofield, Nicole Esteban, Kostas A. Katselidis and Graeme C. Hays (2019) Drones for research on sea turtles and other marine vertebrates – A review. *Biological Conservation* https://doi.org/10.1016/j.biocon.2019.108214.

Further Information

José J. Lahoz-Monfort - jose.lahoz@unimelb.edu.au

Chris Pocknee - c.pocknee@uq.net.au

Threatened Species Recovery Hub
National Environmental Science Programme

Cite this publication as NESP Threatened Species Recovery Hub. 2021. Improved biodiversity monitoring with thermal cameras, Project 3.2.3.2 Research findings factsheet.

This project is supported through funding from the Australian Government's National Environmental Science Program.