**Rabbit-Free Australia Grant Report**

## Title of Project:

A comparison of heatwave impacts on rabbits and native burrowing mammals. Will a changing climate disadvantage rabbits?

## Introduction

Heat waves are increasing in intensity, frequency and duration under climate change (Fig. 1). Global modelling predicts that heat waves will become hotter and longer over the next few decades (Stillman 2019). Heat waves are particularly common in arid areas and **understanding the effects of heat waves on rabbits and other desert mammals is important as more than 70% of Australia is within these arid and semi-arid zones.** These ecosystems will soon be exposed to more intense heat waves than ever before.

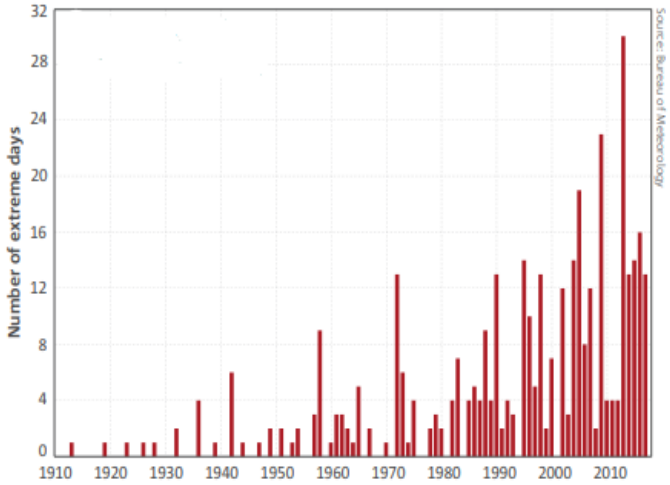



Fig. 1: The frequency of extreme heat events is increasing. Source: BOM State of Climate 2018

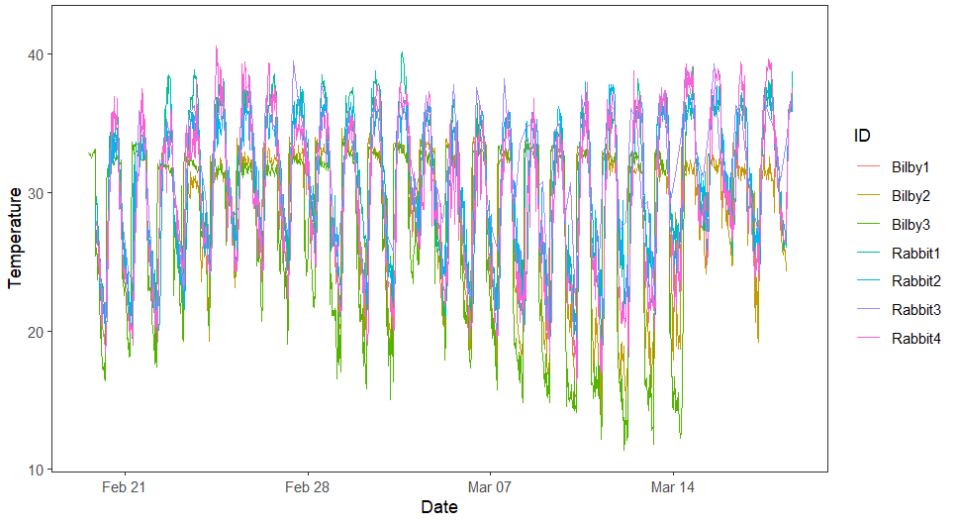
Heat waves affect mammal species in different ways depending on species attributes (physiology, behaviour, plasticity) and environmental attributes such as access to heat refuges. Heat waves have lethal and sublethal effects. Lethal effects occur through hyperthermia when animals are unable to dissipate heat fast enough relative to the heat produced metabolically or acquired through the environment. Hyperthermia occurs due to an animal's inability to maintain its body temperature through its behaviour (seeking thermal refuges, reducing activity) and its physiology (efficiency of evaporative cooling, vasodilation). These parameters can, in turn, be related to abiotic factors such as access to moisture (for evaporative cooling) and effective heat refuges (burrows, crevices, shade). Most of the work on heat wave impacts has concentrated on birds and reptiles with few studies on mammals. The sublethal effects of heat waves include changes in bird sperm production, offspring size, timing of egg hatching and reduced body mass. Heat can change an animal's pattern of behaviour, reduce foraging time and lead to long term adverse effects. A single heat wave during development can strongly reduce future reproductive success. Different susceptibility to heat waves may mean some mammal species will increase in distribution and abundance under changing heat regimes and others will contract in range or become locally extinct.

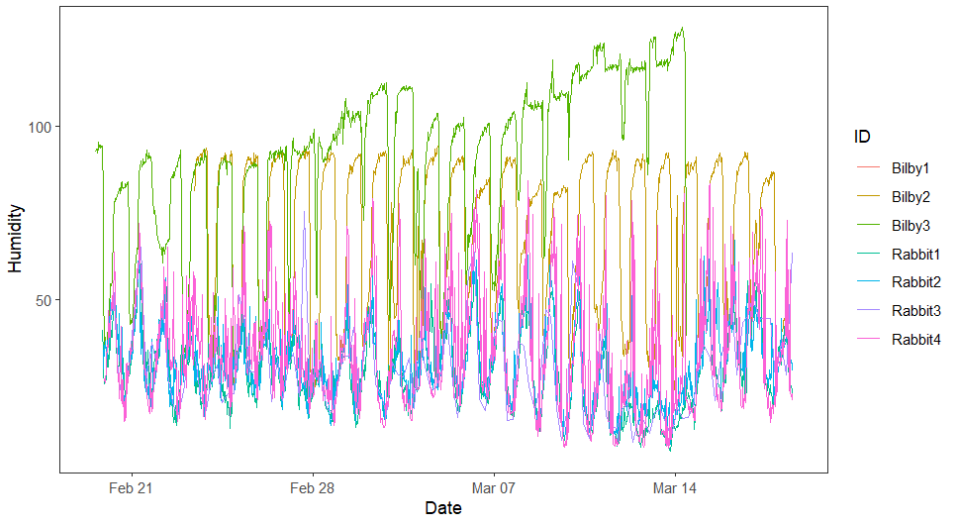
Heat waves impacts on rabbits may include increased mortality, changes in behaviour and burrow use and ultimately changes in their distribution in arid areas, possibly giving some native mammal species an advantage and enabling their recovery. Although rabbits can escape the heat by residing in burrows there are several reasons why they may still be more susceptible to heat waves than native burrowers. Marsupials typically have a lower body temperature (by 1.0-3.0ºC), a lower basal metabolic rate (by 30%), and display a greater daily range of body temperature (2-6ºC), than eutherians such as rabbits (0.5-1.5ºC) possibly giving them an advantage during times of extreme heat (Gaughan et al. 2015). The high metabolic rate of mammals means even if they rest within thermal refuges such as burrows or rock piles during the day, they must still become active and forage at night when minimum temperatures can exceed 35ºC during prolonged heat waves. Night time temperatures during heat waves are more closely correlated with human deaths than daytime maxima. Rabbits are also susceptible to humidity and have a relatively low thermal neutral zone of 18 to 21 degrees, suggesting that any temperatures above this range require heat dissipation.

We compared the impacts of heat waves on rabbits and similar-sized native burrow-dwelling mammals such as bilbies and bettongs. We attached GPS collars that recorded humidity, fine scale activity, location and temperature, and monitored their survival, behaviour, burrow use, breeding and body condition during and outside of heatwaves. We conducted this work at Arid Recovery (South Australia), an arid zone study site where rabbits are present in high abundance. Results will help inform effects of heat waves on desert mammal assemblages and understand the present and future limits of rabbit distribution in Australia.

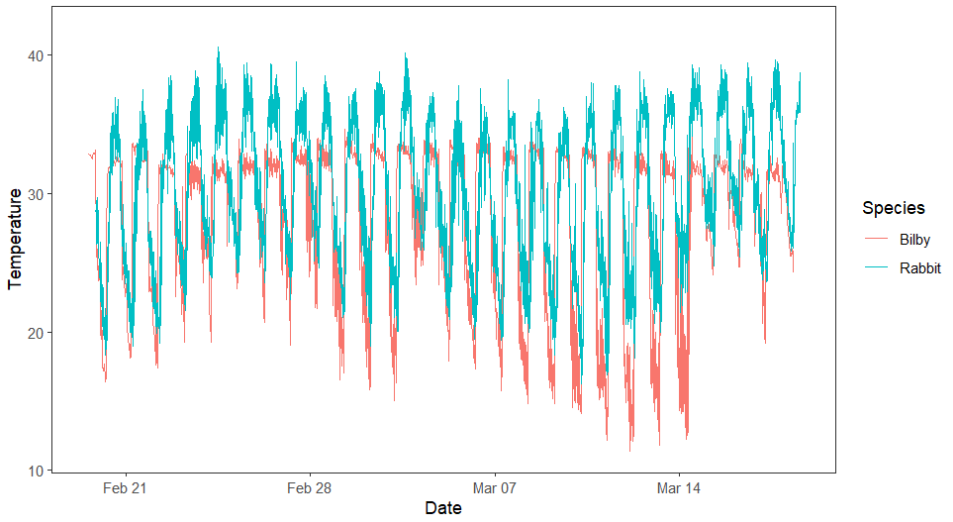
**Methods and Results**

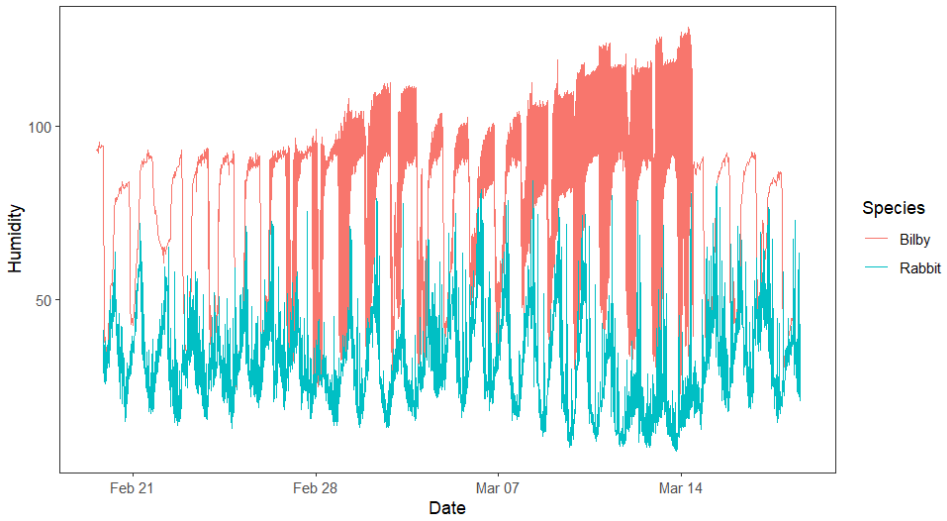
In Summer 2021/22 we attached a combination of VHF and iButton data loggers to three bilbies and four rabbits which were tracked concurrently (see figures below).






When comparing between rabbit and bilby data, rabbits were consistently exposed to higher temperatures than bilbies while their humidity levels were consistently lower. This suggested that rabbits were coming to the entrance of their burrows, or leaving them altogether, to escape high burrow humidity. Rabbits were exposed to temperatures up to 40 degrees, several degrees above their core temperature suggesting they were thermoregulating and dissipating heat. The fact that rabbits were on the surface at this time meant that humidity was low and heat could be effectively lost through evaporative cooling via panting and through vascodilation in the ear. However, the heat index for the European Rabbits suggests that it is very susceptible to high temperatures, particularly in humid conditions. In comparison, bilbies remained in their burrows during the day regardless of temperature. This was reflected in higher humidity and lower temperatures recorded on the dataloggers, with bilbies rarely being exposed to temperatures above 30 degrees C. Bilbies can tolerate extremely high humidity, with levels often reaching 90%.

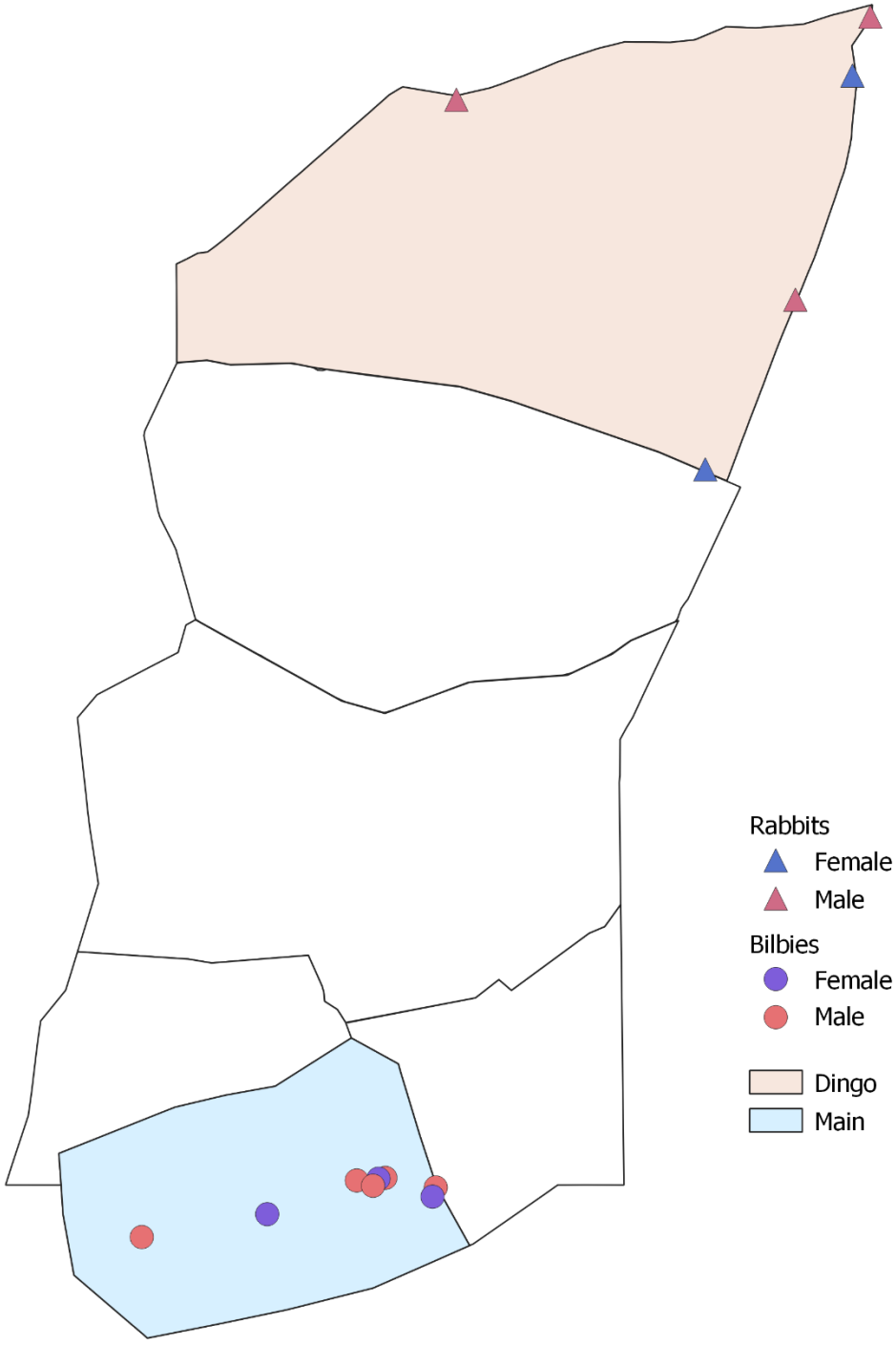





A PhD student (Jack Bilby) started in mid 2022 and from October to December 2022 we assessed the use of accelerometers and GPS combinations with VHF transmitters on three bilbies and two rabbits for short-term trials. From January 2023 onwards, we deployed seven rabbit collars (two accelerometer, four GPS-only, and one GPS/iButton combo) and eight individual bilbies for twelve total rounds (six accelerometer, five GPS-only, and one GPS/iButton combo). Each round lasted between 20-40 days, based on the battery life of the GPS and memory limit of the accelerometer and encompassed five periods with multiple days above 40 degrees.

| **Species** | **Accelerometers** | | **GPS Units** | |
|---|---|---|---|---|
| | *Total Individuals* | *Total Days* | *Total Individuals* | *Total Days* |
| Rabbit | 2 | 43 | 5 | 100 |
| Bilby | 6 | 162 | 6 | 90 |

We collected a significant amount of data from summer 2022/23 and most is yet to be analysed in detail. Training on accelerometer analysis in underway and all data are currently being cleaned and prepared for analysis. Unfortunately, significant heat waves were not recorded at our study site in 2022/23 so we hope to extend the work until 2023/24. Climate projections are suggesting this summer will be very hot with above average temperatures. To confirm whether rabbits are leaving their burrows during the hottest part of the day, we will include behavioural observations of both species as a focal point in the 2023/24 field season. Additionally, on hot nights, we will observe both rabbits and bilbies for 30-minute periods. After assessing the best method to attach an iButton and a GPS on the same animal, this will be our standard procedure next summer (2023/24). We hope to have ten animals of each species (five accelerometers and five GPS/iButton combo) active consistently next summer.




Location of bilbies and rabbits used during the 2022/23 field season