Science for Saving Species

Research findings factsheet

Project 4.1.2

Threatened Species Recovery Hub

National Environmental Science Programme

Determining the Goldilocks Zone to allow threatened small mammal populations to survive outside fenced reserves on mainland Australia: An experimental trial reintroduction of eastern bettongs.

In brief

Although once widespread, the eastern bettong has been driven to extinction on mainland Australia. Foxes are one of the primary drivers of this decline, and wild populations of eastern bettongs now only persist in Tasmania where foxes are absent.

Mainland reintroduction efforts for the eastern bettong have so far concentrated on fenced sanctuaries where feral predators are absent. As these fenced reserves represent only a tiny proportion of the Australian landscape, a longer-term goal is to be able to re-establish eastern bettongs outside of fenced reserves.

In collaboration with the ACT Government and Woodlands and Wetlands Trust, we experimentally trialled the reintroduction of bettongs to an unfenced area of good habitat in the Lower Cotter Catchment, ACT, in conjunction with an extensive and adaptive fox control program. We tested whether fox predation pressure could be reduced sufficiently to allow the bettong population to persist, and whether some level of fox predation could drive bettongs to adapt predator-resistance.

The trial had important findings, with some individuals surviving more than 400 days. Further, the bettongs that survived the longest tended to be larger.

This trial has advanced our understanding of the fox control requirements needed to establish bettongs on mainland Australia substantially, and has demonstrated a potential upper threshold of tolerance of bettongs to foxes. The principles could also be applied to other predators. It is a pivotal step forward toward the eventual re-establishment of bettongs and other small mammals in broader areas of the Australian landscape.

Releasing an eastern bettong at the study site. Image: Adrian Manning

Background

A large component of Australia's biodiversity crisis is the local loss or extinction of animal species. In response, there has been significant investment in reintroductions of species to their historic ranges when the pressures that led to extinction have been reduced or removed. Predation by native and exotic predators, however, remains a barrier to success for many reintroductions.

Over the past 200 years, Australia has seen the highest rate of mammal extinction on earth, with mammals within a critical weight range of 35g to 5.5kg most affected due to predation by the European red fox (*Vulpes vulpes*) and the feral cat (*Felis catus*). Populations of some threatened species now exist only in Tasmania (where cats are established but foxes are not), offshore islands, or feral-proof sanctuaries. The next critical step for these native species is to return populations outside of predator-free areas, 'beyond-the-fence', on the Australian mainland.

Given our current inability to completely eradicate exotic predators from the mainland of Australia, how can we achieve successful small mammal reintroductions?

Australian National University

ACT Government

Woodlands & Wetlands Trust

Background (continued)

A solution could be to drive adaptation of reintroduced animals towards predator-resistance by exposing them to low levels of predation. We propose the concept of a 'Goldilocks Zone' – the 'just right' levels of predation needed to drive selection for predator-resistant native species, while ensuring populations persist (Figure 1).

In this study, we explored the Goldilocks Zone for the eastern bettong (*Bettongia gaimardi*) as part of an experimental trial reintroduction conducted within an adaptive management framework. The eastern bettong had been extinct from mainland Australia for over 100 years, until it was successfully reintroduced to predator-proof sanctuaries in the Australian Capital Territory. It has been established that the closely related woylie (*Bettongia penicillata*) can live beyond-the-fence in predator-controlled areas in Western Australia. We were interested in what conditions would be needed in eastern Australia to allow the eastern bettong to do the same.

Aim of the research

Using the eastern bettong as our study species, we aimed to determine the Goldilocks Zone for predator exposure that would enable small Australian mammals to adapt to living in an environment with some exposure to exotic predators without ongoing population supplementation. We wanted to understand under what conditions it could be possible for an eastern bettong population to persist despite some exposure to foxes, and to adapt predator resistance. Overall, we aim to develop a pathway for returning speciesto the wild beyond fenced areas.

What we did

We conducted an experimental trial reintroduction of eastern bettongs in the Lower Cotter Catchment in the Australian Capital Territory, in partnership with the ACT Government and the Woodlands and Wetlands Trust.

Prior to the reintroduction we implemented a comprehensive and adaptive fox control regime which began in May 2015. We used poison baits to suppress the fox population within our core study area. Then we created a buffer zone using a combination of poison baits and poison capsule ejectors. The poison-baited buffer zone reduced new fox immigration rates into the core area that we had reintroduced the bettongs to. The low number of foxes that survived their entry to the core study area provided the low level of predation that we predicted would drive selection for predator-resistant bettongs.

To detect foxes and other predators we used camera traps at 59 sites from May 2015 to January 2018. From camera trapping, we recorded animal presence or absence for each camera every 24 hours (a total of 19,218 observations). We tested effectiveness of the fox control regime based on ground bait take, ejector bait take and camera detections. We looked at the rate of bait take by foxes, based on the proportion of baits left out for 14 days that were taken. We used the rate of bait take to indicate predation levels in the area.

After an intensive knockdown program for foxes, we released 46 eastern bettongs into the study area in two cohorts. We released 27 bettongs from August to November 2016 and 19 bettongs between May and July 2017. We used VHF radio-tracking collars to monitor the bettongs during the study.

Not all bettongs survived to the end of the trial. We compared how long bettongs survived relative to fox population activity to calculate the level of fox activity that would allow a population to persist while also potentially driving selection for bettongs that survived longer. We used a range of statistical analyses to estimate the Goldilocks Zone using the program R. This project, including the experimental protocols, was approved by the ANU Animal Ethics and Experimentation Committee.

Radiotracking the eastern bettongs. Image: Adrian Manning

What we found

Several of the eastern bettongs introduced into the study site survived for the full length of the experiment, more than 450 days.

We used: 7,047 buried ground baits of which 21% were taken; and 2408 ejectors of which 16% were activated. We detected foxes on cameras 2.3% of the time (450 times out of a total of 19,218 24-hour observations). We found that fox activity was highest in April and May of 2015 and declined for the following two years, indicating that our poison-baiting program was effective at reducing fox populations in the study area.

Predation, mainly by foxes, had a variable impact on bettong survival. For the first cohort released, 47% of bettongs survived for less than 170 days (low survivorship), 34% survived between 170 and 350 days (high survivorship) and 19% survived beyond 350 days (very high survivorship). For the second cohort released, 42% survived less than 50 days and 58% survived up to 240 days when the trial ended.

In months when fox bait take increased, there tended to be more bettong deaths for the high and very high survivorship groups. Conversely, there was no relationship between the number of bettong deaths in the low survivorship groups and the probability of bait being taken. This means that the bettongs with a low survival were preyed upon regardless of the apparent fox density.

For the first two years, the bettongs were living freely in the presence of foxes with low predation pressure. However, in May 2017 predation levels increased to an undesirable level despite continuation of the ejector and baiting regime. As a result, the previously predator-resistant bettongs succumbed to predation. We interpreted this increase as fox activity having crossed the upper threshold limit for the Goldilocks Zone (Figure 1).

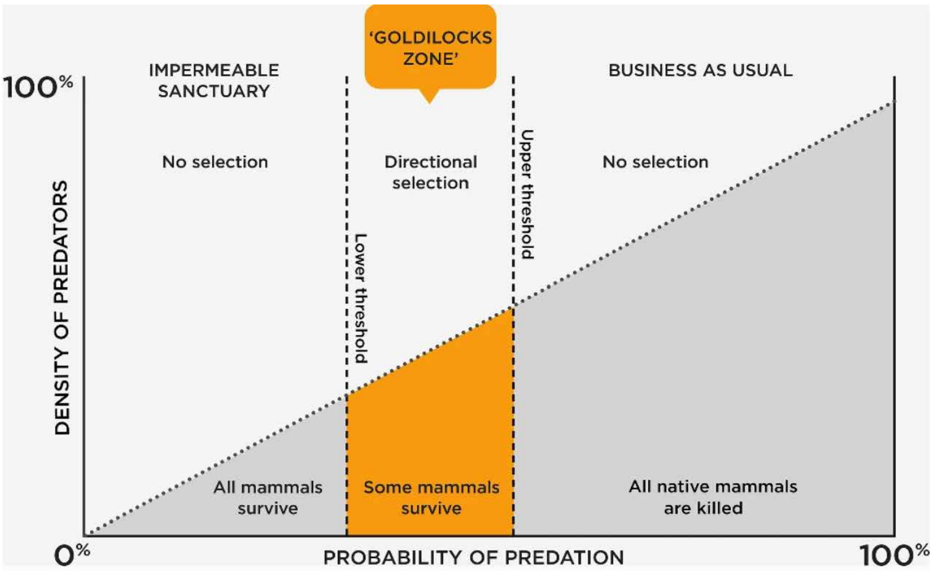

Figure 1. A conceptual diagram of the Goldilocks Zone of predation pressure. To drive selection, the level of predation should be enough to select individuals that have traits that increase their likelihood of survival. If the predation is too high (to the right of the upper threshold of the Goldilocks Zone), then all individuals will be preyed upon without the opportunity to pass heritable traits onto their offspring. If predation is too low (to the left of the lower threshold of the Goldilocks Zone), then those traits crucial for predator-resistance will not be selected for in individuals (Evans et al. 2021).

We determined from our data that the best measure of predation pressure in our experiment was bait take. We estimated the upper threshold of the Goldilocks Zone to occur when 12% of baits were taken. Given bait take was around 80% at the start of the program this is an 85% reduction in the pre-project fox predation pressure, or 15% of the background predation pressure level.

Our study was not long enough to determine the lower threshold of the Goldilocks Zone, however, clearly some bettongs in our study survived a long time (> 1 year) while others succumbed to predation quickly. This difference suggests that some selection of bettongs for predator resistance did take place.

Release weight was the only predictor of survival in our statistical model, and only for the first cohort released. There was a weak trend that the heavier the bettong was at release, the longer it was likely to survive. Bettongs in the very high survival group in the first cohort were all at least 1.535 kg, and the two heaviest bettongs demonstrated high survival.

Eastern Bettong.
Image: Adam McGrath

Implications and future research

This study demonstrates that it may be possible to reintroduce small mammals into areas outside fenced sanctuaries in the presence of exotic predators, as long as predation pressure can be sufficiently reduced and maintained within the Goldilocks Zone. This is an important result, because feral predators are unlikely to be completely eradicated from mainland Australia in the near future. Our results suggest that reducing predation but maintaining it at a certain level could establish a Goldilocks Zone that could drive selection for bettongs with predator-resistant traits.

Our work contributes to a growing body of scientific research that explores how to harness evolutionary processes to combat the challenges posed by animal management and conservation beyond-the-fence in Australia. Our collaboration adds to knowledge that will help managers to reverse the loss of critical weight range mammals that have been decimated by exotic predators on the mainland of Australia, to enable these species to be widespread once again.

Our findings suggest that there could have been selection taking place in the bettong population. More research is needed on how to maintain fox (and other predator) activity below the upper Goldilocks threshold and to determine whether low predator density results in changes in behaviour or inherited traits that increase predator resistance in subsequent generations of small mammals.

More research needs to be done on establishing self-sustaining populations of bettongs in the presence of predators. We suggest that future research should also investigate whether the animal size or any behavioural trait is associated with increased predator resistance over the long term.

Our result offers hope that continued refinement of tactics, in a series of steps within an adaptive management framework could ultimately result in establishing bettongs and other mammals in more places on mainland Australia.

RIGHT: The Lower Cotter Catchment in the ACT where the study was conducted. Image: Adrian Manning

Cited material

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Further Information

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