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Landscape-scale factors determine occupancy of the critically endangered central rock-rat in arid Australia: The utility of camera trapping

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ABSTRACT

The challenges of sampling rare fauna limit efforts to understand and mitigate the factors that restrict their distribution. Camera traps have become a standard technique for sampling large mammals, but their utility for sampling small, rare species remains largely unknown. The central rock-rat (*Zyzomys pedunculatus*) is critically endangered and restricted to rugged range country in central Australia. Using *Z. pedunculatus* as a focal species, we sought to evaluate the effectiveness of camera trapping for sampling small mammals in this environment and to better understand the factors driving the occurrence of this species. We installed baited camera traps at 50 sites across 1795 ha of core refuge habitat for *Z. pedunculatus*. We recorded all six species of small mammals known previously from this area, including the highly detectable *Z. pedunculatus* at five sites. Occupancy modelling showed that distance to the nearest occupied site was the most important predictor of *Z. pedunculatus* occurrence, suggesting that this rodent occurs in discrete sub-populations within the matrix of refuge habitat. Fire history and ruggedness may also influence occupancy of *Z. pedunculatus* at the landscape-scale and could assist in locating additional sub-populations. At the site-scale, occupancy of *Z. pedunculatus* was high and there was no clear influence of any site-scale variables. Management of *Z. pedunculatus* will require protection and expansion of known sub-populations. We conclude that camera trapping provided useful and cost-effective insight into the factors limiting rock-rat distribution, and predict that it will become a standard tool for sampling rare small mammals in difficult-to-access environments.

1. Introduction

The challenges of sampling rare or geographically restricted fauna are a major limitation to better understand the factors that limit their occurrence (Dixon et al., 1998; Gu and Swihart, 2004). This is a particular problem for threatened species, where lack of information can result in inefficient allocation of resources and hamper efforts to identify and mitigate threatening processes (McDonald-Madden et al., 2011). Given that funding for conservation programmes is limited globally (James et al., 1999), sampling threatened species relies on the development and implementation of cost-effective methods that balance efficiency with accuracy and precision (Silveira et al., 2003).

One important development in recent decades is the use of camera traps for sampling wildlife. Depending on the objectives, camera traps may offer advantages over traditional sampling methods, such as live-trapping and direct observation. For example, they allow for continuous monitoring of a location for weeks or months, without the presence of a human observer (Vine et al., 2009). In addition, disturbance and associated stress to wildlife is likely to be minimal as cameras remove the need to detain and handle wildlife, as is required when live-trapping (De Bondi et al., 2010). Further, for uniquely patterned fauna, images from camera traps allow for the use of capture–recapture analysis (Karanth, 1995; Soisalo and Cavalcanti, 2006), while developments in occupancy modelling mean that robust estimates of site occupancy can be calculated with detection/non-detection data derived from camera images (Linkie et al., 2007; Sollmann et al., 2013).

Although predominantly used for medium-to-large mammals, camera traps are showing promise for sampling small mammals. By moving from the typical horizontal mount to a vertical position (camera facing the ground), maintaining a standard height from the ground, and using an attractant bait, numerous small mammal species can be readily detected and reliably identified to species level (De Bondi et al., 2010; Rendall et al., 2014). To date, though, there have been very few direct tests of the efficacy of camera trapping for small mammal detection, and it remains unclear how readily the method can be applied across different habitats and land-use types. A recent study by De Bondi et al.

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(2010) showed that, for an area in temperate southern Australia, camera trapping was a more cost-effective method for small mammal detection than live-trapping. These authors concluded that camera traps had the potential to increase the replication and spatial coverage of small-mammal sampling programmes. Similarly, Rendall et al. (2014) found camera trapping to be an efficient method of detecting invasive rodents in an area of high conservation value. They reported advantages of cameras for detecting trap-averse species and in limiting disturbance to target and non-target species. Importantly though, the efficacy of camera trapping for small-mammal surveys has not been tested in challenging environments such as arid systems where rare small-mammals are often very sparsely distributed, or in situations where the terrain imposes logistic challenges.

The central rock-rat (*Zyzomys pedunculatus*) exemplifies the challenges associated with sampling rare species in difficult-to-access environments. One of Australia's rarest mammals, this endemic and critically endangered (IUCN red list; Woinarski and Morris, 2008) rodent has contracted in extent of occurrence by >90% in the last 100 years and is currently known from a limited area of mountainous terrain west of Alice Springs in the Northern Territory (McDonald et al., 2013, 2015a). The central rock-rat exhibits classic 'boom-bust' population dynamics that are directly underpinned by extreme fluctuations in primary productivity in time (Edwards, 2013a; Letnic and Dickman, 2010). Following well above-average rainfall events, this species, as with many desert rodents, may undergo population irruptions and become locally abundant in a variety of rocky situations (e.g. see Edwards, 2013a). However, with the inevitable return to more typical dry and low-resource conditions, this species contracts to core-habitat patches (refuges) during its non-irruptive population phases (McDonald et al., 2013; Pavey et al., 2014).

Recently, significant progress has been made in the circumscription of core-habitat variables for the dry-time refuges of *Z. pedunculatus*, allowing for increased predictability of occupancy area and population size (McDonald et al., 2013). Specifically, it is now known that central rock-rat refuges are effectively confined to high-elevation (>1000 m) quartzite ridges and mountain peaks (McDonald et al., 2013). However, attempts to further refine population and habitat parameters are at present severely constrained because standard live-trapping methods are too labour- and resource-intensive to generate sufficient information within the context of current budgetary constraints (McDonald et al., 2013). As a result, the factors limiting the distribution and size of *Z. pedunculatus* populations remain unknown.

Recent trials using camera traps have provided an indication that cameras may have high utility for the study of this and other sparsely-occurring small mammals in arid settings (McDonald et al., 2015a). These trials have, however, been opportunistic and small-scale, and more rigorous assessment of the technique is required. Here, we assess the utility of camera traps for detecting and understanding the factors that limit occupancy of *Z. pedunculatus* in the West MacDonnell National Park in the Northern Territory, Australia. Representing the core habitat of *Z. pedunculatus* and some of the most rugged and remote terrain in Australia, this park is an ideal location to evaluate the potential utility of camera traps where access is difficult and there are size and weight restrictions on equipment. Focusing on core *Z. pedunculatus* refuge habitat, and using *Z. pedunculatus* as our focal species, we aimed to: 1) evaluate the potential of camera traps for detecting *Z. pedunculatus* and other small mammals, 2) better understand the factors influencing occupancy of *Z. pedunculatus*, and 3) provide management direction for the conservation of *Z. pedunculatus*.

2. Methods

2.1. Study area

Our study was located in the 2592 km^2 West MacDonnell National Park (NP) in the MacDonnell Ranges bioregion of the Northern Territory (NT), Australia (Fig. 1). This iconic national park extends 160 km west from Alice Springs and includes the most rugged and high elevation (to 1500 m) uplands in arid Australia. Climate is semi-arid with highly variable rainfall (mean annual rainfall at Alice Springs Airport =

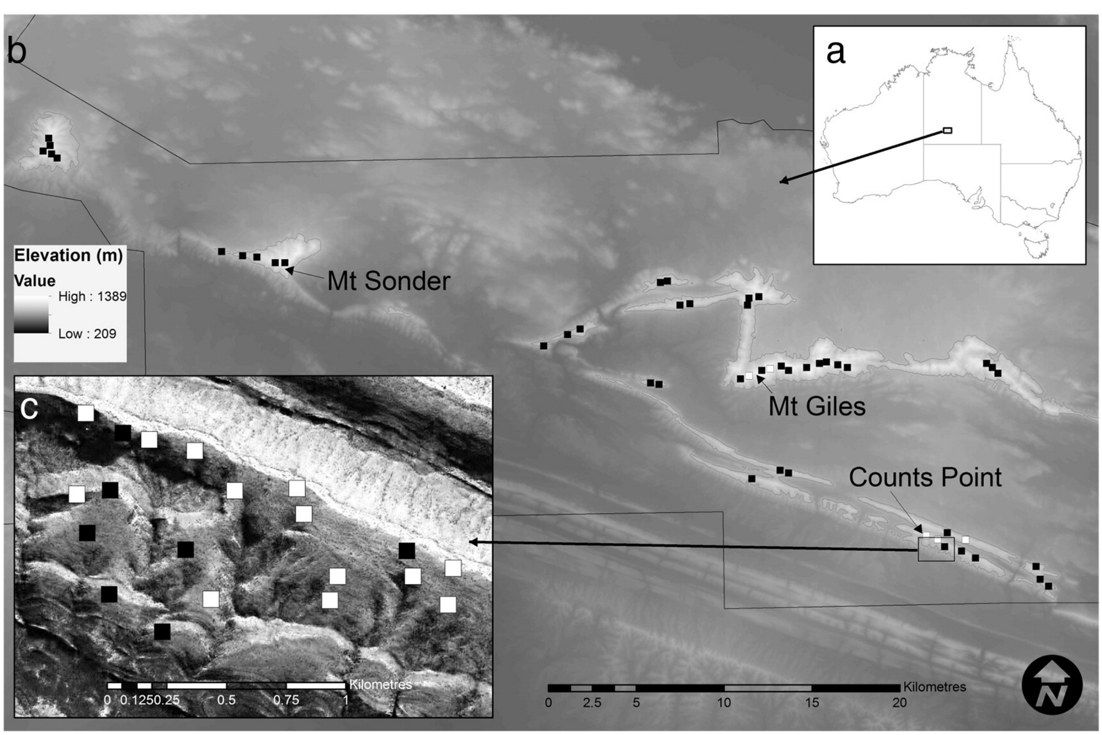

Fig. 1. Maps showing: a) the study area in the Northern Territory, Australia; b) the locations of the 50 camera trap sites on the higher elevation (>950 m) quartzite landforms of the West MacDonnell NP (sites not to scale); and c) the locations of the 20 camera traps in the intensively sampled area. White and black squares represent sites where *Zyzomys pedunculatus* was recorded to be present or absent, respectively. Background digital elevation model and satellite imagery courtesy of Geoscience Australia.