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Special Issue Article: Tropical rat eradication

## Best practice guidelines for rat eradication on tropical islands

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## ABSTRACT

Invasive vertebrates are a leading cause of extinction on islands and rats (*Rattus* spp.) are one of the most damaging to island ecosystems. Methods to eradicate rats from islands are well established and there have been over 580 successful eradications to date. Increasingly, rat eradications are being implemented on tropical islands, a reflection of the need to protect the threatened biodiversity in the tropics. Yet rat eradications on tropical islands fail more frequently than those in temperate climates. In an effort to identify the main reasons for the lower success rate on tropical islands and possible solutions, a workshop was convened with 34 experts in rat eradication, tropical rodent and island ecology and toxicology. The workshop focused on projects using aerial broadcast of brodifacoum, a 2nd generation anticoagulant, because this approach has provided the highest success rate for eradicating rodents from islands. The workshop participants reviewed previously identified challenges to successful rat eradications on tropical islands including increased insect and crab densities resulting in competition for bait, year round or unpredictable timing of breeding rats and increased or unpredictable availability of alternative, natural foods. They also identified a number of new, likely reasons for the lower success rate on tropical islands and provided recommendations for how to address these risks in the planning and implementation of rat eradications. While the success rate of aerial broadcast rat eradications in tropical environments is quite high at 89% ( $n = 47$ ), it is hoped that by following the recommended best practices provided in this paper, future success rates will be closer to the 96.5% ( $n = 116$ ) demonstrated for aerial broadcast rat eradications on temperate islands.

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## 1. Background

In an effort to address the negative impacts of introduced rats on islands, eradication techniques were developed (Howald et al., 2007; Broome et al., 2014). As practitioners learned from both successes and failures, new tools and methods were developed and refined. Techniques for the aerial broadcast of rodenticides were developed in the 1980s (Townsend and Broome, 2003) and this approach now provides the highest success rate for eradicating

rodents from islands as well as enabling eradications to be carried out on larger and more topographically complex islands (Parkes et al., 2011). Much of the work developing the aerial broadcast approach was conducted on islands around New Zealand. Based on this experience, the New Zealand Department of Conservation has developed Current Agreed Best Practices (CABP) for implementing aerial broadcast rat eradications in New Zealand (Broome et al., 2014). The CABP are specific to the temperate climate islands of New Zealand. While it is critical that rat eradications are planned using direct knowledge of the target island and following local regulations, these CABP provide valuable information for planning and implementing rat eradications outside of New Zealand, especially in other temperate areas.

Increasingly, rat eradications are being attempted on tropical islands, in part in response to the unique biodiversity and high

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numbers of threatened species at risk of extinction due to introduced rats (Dirzo and Raven, 2003; Keitt et al., 2011). Many eradications on tropical islands have been successful despite the presence of conditions that may increase risk of eradication failure, such as increased bait competition (Griffiths et al., 2011), lack of seasonal variability and year round rat breeding (Wegmann et al., 2011), and increased natural resource availability (Merton et al., 2002). Indeed, a recent analysis of historical rat eradications indicates success rate is slightly lower on tropical islands (Holmes et al., This Issue). Based on analysis of the Database of Island Invasive Species Eradications (DIISE) using island latitude, aerial broadcast operations targeting rats on temperate islands have a success rate of 96.5% ( $n = 116$ ) and on tropical islands it is 89% ( $n = 47$ ) (DIISE Partners, 2014).

In an effort to better understand the reasons underlying the lower success rates for tropical rat eradications and identify possible solutions a global review was initiated. The review had three main components: (a) an historical review of rodent eradications using the DIISE to look for trends (Holmes et al., This Issue), (b) in depth reviews of four recent unsuccessful rat eradications on tropical islands that used aerial broadcast of brodifacoum and (c) a workshop that convened 34 global experts in eradications, tropical rodent and island ecology and toxicology (Appendix B). The Recommended Best Practices (RBP) presented here were developed by the steering group for the workshop, with assistance and review by the workshop participants and highlights key issues associated with eradications on tropical islands and are not designed to provide guidance on all aspects of planning and implementing an eradication. Additional resources such as the DOC Current Agreed Best Practice for temperate islands and the Pacific Invasives Initiative Resource Kit (<http://rce.pacificinvasivesinitiative.org>) can assist with project planning and should be combined with expert input, external review and extensive knowledge of the local environment.

The review that was undertaken as part of the workshop, and thus the RBP presented here, are restricted to rat species (*Rattus* spp.) and aerial broadcast of brodifacoum, the most commonly used 2nd generation anticoagulant rodenticide in broadcast eradications (Howald et al., 2007). House mouse (*Mus musculus*) eradications were excluded because there was insufficient data on eradications in the tropics for meaningful analysis. It is relevant, however, that house mouse eradications have been reported to fail at a much higher rate than rat eradications (62% and 69% success rate reported in MacKay et al. (2007) and DIISE Partners (2014), respectively). Presumably the same challenges to rat eradication in the tropics also apply to mouse eradications. But recent analyses showing that mouse eradications in all latitudes using aerial broadcast of 2nd generation anticoagulant baits have a very high probability of success suggest tropical mouse eradications may not be as challenging as previously thought (15 of 16 mouse eradication attempts since 2005 have been successful, DIISE Partners, 2014).

The RBP presented here are not designed to assist in determining the best method for eradicating rats on a specific island. Hand broadcast, bait stations, toxicants other than 2nd generation anticoagulants, and traps have been successful at eradicating rats on islands and should be considered when assessing project feasibility. Prior to settling on a proposed method, issues such as efficacy, risk to non-target species, island size and accessibility are among the criteria that must be assessed and these topics should be included in a feasibility study. However, many of the RBP presented herein will also be relevant to other tools used for the eradication of rats on tropical islands.

Similarly, there is a need for new tools and approaches to rat eradications on islands to reduce non-target risks and increase social and regulatory acceptance (Campbell et al., This Issue);

development and testing of new tools and approaches should be prioritized. However, we are facing an extinction crisis (Barnosky et al., 2011) and many threatened species cannot wait for the uncertain promise of future tools. Carefully planned and executed eradications using the existing tools of aerial broadcast of 2nd generation anticoagulants should thus be considered a key part of efforts to protect threatened species and restore island ecosystems (Townes et al., 2013).

The RBP for aerial broadcast rat eradications on tropical islands will evolve as more information becomes available. This paper reflects the current recommendations at this point in time following the workshop and the RBP will be maintained and made available through the Pacific Invasives Initiative website (<http://www.pacificinvasivesinitiative.org>).

## 2. Methods

A challenge faced when evaluating unsuccessful eradication projects is that there is rarely one clear reason for the failure. Rather, there is a suite of possibilities that each have varying probabilities. The approach taken in the tropical rat eradication review workshop was to first learn as much as possible from previous rat eradications. This was accomplished through a review of the Database of Island Invasive Species Eradications (DIISE), an online database of all reported successful and unsuccessful invasive vertebrate eradications on islands. The results of this review are discussed in depth in Holmes et al. (This Issue). This analysis confirmed the underlying assumption of the tropical rodent eradication review by demonstrating a negative correlation between a measure of tropical climate (temperature) and project success. While there have been many successful eradications of rats on tropical islands, the rate of success regardless of method is lower on tropical islands (81%,  $n = 285$ ) than for temperate islands (91%,  $n = 365$ ).

The other key piece of historical information supporting the review was the detailed analysis of four recently implemented but unsuccessful rat eradications using aerial broadcast of brodifacoum: Desecheo Island, Caribbean; Henderson Island, Pitcairn group; Wake Atoll, western tropical Pacific; Enderbury, Phoenix archipelago. The approach to these project reviews helped guide the structure of the workshop, which separated the key potential reasons for project failure into two main categories: bait availability – all rats **could** not eat a lethal dose of bait, and bait palatability – all rats **would** not eat a lethal dose of bait. Other possible reasons for eradication failure such as reinvasion and resistance were not considered in this review because they were not considered unique to tropical islands. The structure of the project reviews conducted by Brown et al. (2013), Brown and Tershy (2013) provided the basis for the recommended review process.

### 2.1. Workshop structure

Thirty-four experts were convened at the University of Auckland for a workshop on 19–21 August, 2013 (Appendix B provides a list of participants). Presentations were made on the review of historical eradications (Holmes et al., This Issue), the suite of recently failed projects and an evaluation of unsuccessful projects that were later implemented successfully (Samaniego-Herrera unpubl. data). These presentations were used to seed a brainstorming session where possible reasons for lower success rate on tropical islands were shared and broken into the two key categories of bait availability and bait palatability.

The leading hypotheses from the brainstorming session were then evaluated by breakout groups of 4 to 8 individuals. These groups reviewed the evidence for and against each hypothesis as

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