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Review of a Large-Scale Pacific Rat Eradication Attempt from an Uninhabited World Heritage Site: Project Approach, Lessons Learnt, and Future Directions

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ABSTRACT: The United Kingdom's Overseas Territories support the vast majority of the globally threatened species for which the UK is responsible. Henderson Island (43 km²), located in the South Pacific and part of the Pitcairn Islands group, is a near-pristine example of a raised coralline atoll and is internationally recognized as a UNESCO World Heritage Site. Pacific (Polynesian) rats, introduced by Polynesian settlers about 700 years ago, have been implicated in the long-term decline towards extinction of the Henderson petrel, the loss of huge numbers of breeding seabirds from the island, and the extinction of endemic species. The eradication of Pacific rats is the only viable management option open to prevent the eventual extinction of the Henderson petrel and is a vital action in maintaining the Outstanding Universal Value of this World Heritage Site. The Royal Society for the Protection of Birds (RSPB), in partnership with the Government of the Pitcairn Islands, undertook a multi-year program of planning, fundraising, and partnership-building work which culminated in a GBP£1.5m (USD\$2.4m) aerial bait dispersal operation in 2011. The work was carried out in August 2011 as part of an international "chain" of eradication operations (Palmyra Atoll, USA, and Enderbury and Birnie, Kiribati) carried out in succession. Seven months after completion of the operation, in March 2012, the first report of a rat sighting was received. This report was verified by a rapid response mission to the island in May 2012, followed by a further expedition to Henderson in November to assess the status of rat and bird populations. Concurrently, the RSPB began an evaluation process, commissioning 3 independent reviews of the entire operation in an effort to identify potential reasons for failure and maximize lessons learnt for the global eradication community. We conclude that a rigorous yet flexible planning process that engages both international expertise and local communities is essential. We make recommendations for consideration in the planning of future operations on Henderson and similar islands worldwide.

KEY WORDS: aerial baiting, brodifacoum, eradication, Henderson Island, Henderson petrel, Pacific rat, *Pterodroma atrata*, *Rattus exulans*, World Heritage Site

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INTRODUCTION

Islands hold a disproportionate amount of the world's biodiversity (Kier et al. 2009, IUCN 2014). The habitats and species dependent on islands are severely threatened by human activity such as habitat destruction (Millennium Ecosystem Assessment 2005) and the introduction of non-native species (Paulay 1994, Courchamp et al. 2003) including rats (*Rattus* spp). Island biodiversity has suffered significant losses due to the introduction of rats (Townes et al. 2006, Varnham 2010). Marine birds and island endemics often lack effective defence mechanisms due to their isolation on islands, rendering them naive to predation by rats (Atkinson 1985, Brooke 1995). Because of the threats posed by rats to island ecosystems, a significant amount of effort has been put into restoring island biodiversity and safeguarding species through rodent eradications (Broome et al. 2005, Howald et al. 2007, Varnham 2010, Keitt et al. 2011, Island Conservation 2012a).

Henderson Island (S 24°20.409; W 128°19.694 at camp site, North Beach) is an exceptionally remote uninhabited island in the central South Pacific. The island is 9.6 km long and a maximum of 5.1 km wide with a total area of 4,308 h, rises 33 m above sea level, is densely forested, and is considered one of the world's least disturbed raised coral islands (Brooke and Towns 2008). The natural value of the island was recognized in 1988 when the United Nations Educational, Scientific and

Cultural Organization designated the island as a World Heritage Site (UNESCO 2014). The island is entirely Crown Land within the UK Overseas Territory of the Pitcairn Islands. The Governor of the Pitcairn Islands is based in Wellington, New Zealand. The Pitcairn Islands Council, consisting of elected members, is responsible for local government and administration of internal affairs and acts in an advisory role to the Governor (Brooke et al. 2004).

The arrival on Henderson of humans and the Pacific (Polynesian) rat (*Rattus exulans*) had devastating consequences for the island's biota. This impact resulted in the extinction of at least 5 out of the 9 landbird species [Henderson sandpiper (*Prosobonia* sp.), Henderson archaic pigeon (family Columbidae), Henderson ground dove (*Gallicolumba* sp.), Henderson ducula pigeon (*Ducula* sp.), Pacific swallow (*Hirundo tahitica*) (Weisler 1995, Wragg 1995)] and at least 6 out of the 22 land snail species (Preece 1995). The significance of the impact of rats on seabird communities was first identified during the Sir Peter Scott Commemorative Expedition to the Pitcairn Islands. Brooke (1995) found that nesting success was low for all 4 petrel species. Egg survival was high but chick survival following hatching was low with an average, across species, of less than 20% of eggs laid yielding fledglings. Observations indicated that this was due to predation by rats with most failures occurring at the early chick stage. The population of Murphy's petrel

(*Pterodroma ultima*) could be sustained through immigration from other islands; however, as Henderson Island is the only known breeding station of the Henderson petrel (*P. atrata*), concern was raised for this species. In a model produced by Brooke et al. (2010a), using data from 1991 and 2003, the current population of 16,000 pairs Henderson petrels may have declined from a population around 5 million pairs when rats arrived. This model concluded that the species was likely to be declining towards extinction unless conservation action is taken.

The RSPB began its involvement with the restoration of Henderson by supporting the production of a feasibility study and draft operational plan for the eradication of Pacific rats in 2008 (Brooke and Towns 2008, Brown 2008). The feasibility study concluded that eradication was feasible and recommended aurally spreading bait using an underslung bait spreader from a helicopter operating off a ship as the most feasible option. Brodifacoum was recommended as the most suitable toxin for the operation (Brooke and Towns 2008) and had proven success in the similar sub-tropical environment of Raoul Island (Broome 2009). Three further research questions needed to be answered before an operation could proceed. Firstly, how to address the potential issue that hermit crabs (*Coenobita* spp.) could eat so much bait that not enough would remain to ensure that all rats could obtain a fatal dose; secondly, to verify whether Henderson's 8 species of endemic snail (mostly achatinellids) would be vulnerable to poisoning; and thirdly, to establish whether it was possible to catch and hold an insurance population of the endemic Henderson rail (*Nesophylax ater*) during an eradication operation. In 2009, a research team visited Henderson for 7 weeks to address these outstanding questions. They were able to successfully address all 3 issues and give the green light for an operation to proceed (Brooke et al. 2010b, 2011; Cuthbert et al. 2012).

This paper describes the process followed by the RSPB from this point with the establishment of a project team and the hiring of a full-time co-ordinator.

PROJECT APPROACH

Initial Planning and Team Structure

Henderson was the largest tropical or sub-tropical island ever targeted for a rodent eradication (Island Conservation 2012a) and was the first aerial eradication project that the RSPB had managed. A full-time project co-ordinator was appointed in January 2010 to assist in co-ordination of the project team, secure funds, manage finances, and lead on the wider non-operational aspects of project planning. Two highly experienced aerial eradication operation managers and a leading eradication pilot were retained, initially on a part-time basis, to progress the technical operational planning, revising the draft operational plan (first in April 2010, then twice again in February and June 2011), and arranging logistics and equipment. Internally, the RSPB prepared the supporting documents required: 1) Ethical Review, 2) Environmental Impact Assessment (EIA), 3) Avicultural Plan, 4) Communications Plan, 5) Biosecurity Plan, 6) Health & Safety Plan, 7) Monitoring Plan, 8) Waste Management Plan, 9) MOU with Pitcairn Council, and 10) Fundraising

Strategy; thereby ensuring legal permissions were in place, liaising with stakeholders, and conducting financial management. An additional role in the pre-project planning was played by the Island Eradications Advisory Group (IEAG) of New Zealand Government's Department of Conservation. This group provided independent expert review of all operational documentation on several occasions and helped shape operational decision-making.

This division of tasks was found to be a very effective approach. Operational managers were enabled and supported in their specialist area whilst free of the (frequently underestimated) wider workload of an eradication project. By preparing supporting documents such as the EIA, the RSPB gained a more in-depth appreciation of the wider issues, which enabled the organisation to engage more effectively with key stakeholders such as the UK Government's Foreign and Commonwealth Office (FCO). In terms of capacity, it did, however, require at least 2 full-time-equivalent posts in the RSPB and increased management costs, in both cases more than originally envisaged.

Working with Pitcairn

Working in partnership with the Pitcairn Government was an essential component of the project. Their involvement was secured from an early stage to ensure buy-in and to identify and meet local concerns. One of the core RSPB team visited Pitcairn at the beginning of 2010 to outline the work programme, seek formal support for the project, and explore how the community would most like to engage/be engaged. This proved a vital part of the set-up process, especially as Pitcairn Island itself had been the subject of a failed eradication attempt in the late 1990s (Bell and Bell 1998). The Pitcairn Government agreed to be a joint partner in the project and mutually agreeable and sustainable ways of working were established. The Government was the only party which had full partner status with the RSPB in the public arena, and the partnership was cemented via an MOU which laid out roles and responsibilities.

A contract was established with the Natural Resources Division (NRD) of the Pitcairn Islands Government. This secured their inputs into the planning process, regular updating of the community, and distribution of the project newsletter on-island. Working through this formal governmental structure was important, not only for building capacity, but also to avoid perceptions of favouring any particular part of the community.

This focus on engagement resulted in 6 islanders (of a total population of c. 50) working on the project during the operational phase as either staff members or volunteers, including 3 of the younger community members. This approach was designed to increase ownership of a rat-free Henderson, as it is Pitcairn Islanders who are responsible for ensuring that biosecurity measures are observed. It is noteworthy that having a mixture of paid and volunteer Pitcairn Islanders did create some frictions. In future programmes, a unilateral approach, one way or the other, should be adopted. For small communities, it may be appropriate to consider a single payment or contribution to the community as a whole to acknowledge and recompense for volunteering effort.

Partnership with Other Pacific Eradication Projects

The feasibility study identified August as the optimum month for an eradication to take place (Brooke and Towns 2008) and the operation was tentatively planned for August 2011. One of the major costs of the operation was repositioning the boat and helicopters to the remote mid- South-East Pacific. The operational managers were able to identify two other Pacific eradication projects scheduled for the months preceding Henderson with whom a partnership approach could be adopted. The opportunity to undertake a joint charter and split repositioning costs was identified. Target timings were such that a single boat and set of helicopters could journey in turn from one project to the next, carrying out eradication operations at each. An MOU was signed with the other two projects: Island Conservation, working with partners to restore Palmyra Atoll (USA), and Eco-Oceania Pty Ltd, working to restore Enderbury and Birnie Islands in the Phoenix Island group (Kiribati).

For various reasons, both projects faced some uncertainty over whether they could definitely proceed in 2011. This uncertainty further extended the time taken to finalise the operational contracts as all parties waited for the others to be ready. Ultimately, partly due to the time taken to raise the funds (and partly due to the time taken for all operational partners to confirm they were proceeding), joint ship and helicopter contracts were only signed in April 2011, just one month before the ship departed Seattle. The project was extremely fortunate that the suppliers were willing to wait so long before finalising contracts, but future operations should not be planned with such tight time margins. It would be preferable to start preparations for contracts in Year 1 of the project with the baiting in the following or subsequent years. Three years of fundraising and planning would be a more ideal timeframe. If required, penalty clauses could be included in case any individual project needs to withdraw.

The partnership of 3 projects brought significant practical benefits to the Henderson Restoration project. As this was the first time that an aerial eradication had ever been conducted off the deck of a ship, operational staff were able to gain valuable experience before reaching Henderson, which was last in the chain of operations. It should be noted that the individual financial savings for the Henderson project were relatively small in the context of the overall GBP£1.5m budget (in the low tens of thousands of pounds) (RSPB unpubl.).

Licensing Arrangements/Regulatory Context

The pesticide chosen for the operation was Pestoff Rodent Bait 20R, as produced by Animal Control Products Ltd. (ACP), Whanganui, New Zealand. This bait was produced as a dyed green compressed cereal pellet containing 0.02g/kg (20 ppm) of the toxin. As Pitcairn had no legislation regarding the use of pesticides, UK law, where the aerial spreading of brodifacoum is not registered, could potentially have applied (Hendry and Dickson 2011). To provide a clear regulatory framework, the Government of the Pitcairn Islands developed and passed its own pesticide legislation during the operational

planning period to create a permitting procedure ahead of commencement.

Identifying the correct licensing authority for the both the helicopter flying and pilot is a crucial component of any operation. In situations such as on an Overseas Territory, the legal situation is not always clear. Additionally, because of the unusual nature of this type of operation, it can often be difficult for civil aviation jurisdictions to understand the process. It was fortunate that the pilot employed during this operation had been working with Aviation Support Services International for similar work on South Georgia (also a UK Overseas Territory) and so had a good appreciation of the objectives and methods (Garden 2012). Gaining operational approvals should not be taken lightly in other parts of the world.

An additional consideration which should be factored into similar projects is the aircraft insurances required. This is usually the responsibility of the helicopter owner (Garden 2012). However, if leasing the helicopters, an aircraft owner that is completely isolated from the operation may not be willing to cover public liability. Insurance arrangements, including Public Liability Insurance, can become unclear with specific efforts required to ensure the owner or leaser has adequate coverage. Using a pillow with sufficient knowledge of these issues was highly beneficial to identifying solutions.

Budget and Fundraising

The RSPB, as an environmental charity, embarked on this project with the need to raise all the funding required from external sources. The original 2008 estimate was GBP £1.3 million (Brooke and Towns 2008) which rose to £1.5 million in the 2011 operational plan and included a 10% contingency allowance (RSPB unpubl.). This difference was partly due to elapsed time between the two estimates and partly due to the second budget estimate being more rigorous. It should be noted that neither of these budgets includes all of the costs incurred by the RSPB; there were significant additional costs in fundraising and project management.

A specific fundraising strategy was developed for the project (RSPB unpubl.). In total, over £1.6m was successfully raised over 2 years, of which £100,000 was for follow-up monitoring. Of this, 40% came from major donors (95 individuals), 30% from Foundations (principally The David and Lucile Packard Foundation), and 30% from the UK Government.

The fundraising was challenging, but in general the mix of target sources worked well, and having a specific fundraising strategy for each of these three potential sources would be recommended for large operations. Of particular value in raising the funds was a high profile fundraising reception for major donors held at the Foreign & Commonwealth Office in London, hosted by the Minister for the Overseas Territories and opened by Sir David Attenborough. This built very good relations with donors and was an excellent tool for engaging politicians and Government stakeholders.

Fundraising would have been easier if there had been more certainty around the timeframe for the operation. The uncertain operational date meant that pledges had to

be sought from major donors rather than donations, increasing the risk that this financial support might not materialise when needed. It would also have been considerably easier to raise the required funds over a 3-year period, rather than 2. It is important to note that, even when meeting the funding goal appeared difficult, the 10% contingency built into the budget was not compromised.

Support and Advisory Committee

A Support and Advisory Committee (SAC) was established during the operational phase. Its was to respond to requests for advice from the Henderson Island Restoration Project Managers on matters relevant to the implementation of the Operational Plan and to allow streamlined decision-making in emergency or other high-risk situations. The SAC was established to manage and unforeseen serious and unexpected issues that could have arisen that were beyond the operational scope, contingencies, and budgets outlined in the Operational Plan. It was expected that such situations would need to be dealt with rapidly by the 3 stakeholder organisations (RSPB, Government of the Pitcairn Islands, UK FCO). The SAC comprised representatives from these organisations, along with an independent technical advisor from Island Conservation. Terms of Reference were established for the SAC which included:

- Provide advice on specific operational matters as referred to them by the Project Managers or RSPB's project team,
- Act as the primary conduit for communication between each of the participating organisations and the Project Managers/RSPB project team, and
- Monitor the implementation of the eradication plan and advise the Project Manager/RSPB project team of the implications of any serious issues that arise during implementation.

Although the SAC was not required, its establishment provided the operational managers with reassurance that they would not be left in the position of deciding whether or not to abort the operation should some unforeseen circumstance arise. This also ensured that, if required, the decision to abort the project would be one of shared input between the key stakeholders and the technical experts.

OVERVIEW OF OPERATION

May 2011

The U.S.-registered vessel, the 155-ft MV Aquila, complete with two Bell 206 Jet Ranger III helicopters and a range of equipment, departed Seattle in May 2011 in order to complete 3 eradication projects in turn. The boat had 2 separate trips to Apia, Samoa, in order to exchange teams and pick up the large quantities of bait required for the separate operations.

July 2011

The 6-person avicultural team arrived at Henderson in early July 2011. The avicultural team were responsible for establishing and keeping a target captive population of 100 -120 Henderson rails during and after the operation. Unprecedented wet weather impacted on the methodology for catching rails and required the team to utilise

other methods and work extremely long hours to establish the desired captive population ahead of the main vessel's arrival (RSPB unpubl.). The avicultural team also made observations of conditions on-island. It was apparent that fruit load on a number of tree and shrub species was relatively high compared to the same time of year in 1991 (Brooke et al. 1996, Brooke et al. 2009). No quantitative information is available to compare 2009 with 2011; however, observations indicated high fruit abundance in the following 3 species: *Cyclophyllum barbatum*, *Myrsine hosakae*, and *Eugenia reinwardiana* (RSPB unpubl.).

August 2011

Upon the arrival of the operational vessel, the island was GPS logged and proved to be considerably bigger than expected with the GPS showing 4,308 hectares instead of the officially recorded 3,700-ha (Torr and Brown 2012). The ship-based baiting application took place on 15-17 August (first drop) and 21-22 August (second drop), successfully distributing a total of 75,075 tonnes of brodifacoum cereal pellets methodically across the island (Torr and Brown 2012). Monitoring indicated that bait pellets remained present on the island for up to a month (Brooke et al. 2011)

November 2011

The avicultural team departed Henderson in late November after successfully releasing the captive rail population and having continued monitoring. At the time of departure, no sign of rats had been recorded for 12 weeks.

OUTCOME OF OPERATION

Seven months after baiting, in March 2012, a visiting expedition reported seeing a single rat on the plateau, supported by brief but partially obscured video footage (Fay 2012). The RSPB mounted a rapid-response trip, arriving in May 2012 and confirmed that rats were present. Subsequent genetic testing, comparing rat samples which had been taken from Henderson before the operation with those taken after, indicated that some rats had survived and that this was not a re-invasion (RSPB unpubl.).

Responding to Failure

There is a paucity of information available on failed eradication attempts for subsequent project managers to learn from, in either pre-operational planning or as a template to follow in the case of failure. The RSPB took the decision to be transparent about the project's failure, to set a new example of best practice, to learn all possible lessons from the operation, and to advance knowledge.

All partners, stakeholders, and major donors were swiftly informed about the persistence of rats. The news was greeted with obvious disappointment but also a clear understanding that the operation had never been without risk. Funders were extremely encouraging in their response with many expressing their continued commitment. This highlights the importance of balancing inspirational messaging with a clear explanation of the risks involved when marketing a rodent eradication project to potential supporters.

The RSPB commissioned 3 independent reviews of the operation, sharing all relevant documentation and

reports with the IEAG, Island Conservation, and eradication practitioners Wildlife Management International Ltd. (WMIL). All 3 reviews concluded that the RSPB had followed international best practice in its implementation of the project and that the exact reason for failure would unlikely ever be known. They did, however, come to slightly differing conclusions as to what they believed might have been the most likely issue, focussing (in no particular order) on unprecedentedly wet pre-operation weather leading to an increase in naturally available alternative food and breeding rat population; the length of time for which bait was available on the ground; and, considering a number of failures which occurred elsewhere, the adequacy of current best practice for tropical or sub-tropical island eradications (IEAG 2012, Island Conservation 2012b, WMIL 2012).

The project co-ordinator visited Pitcairn in November 2012 to demonstrate RSPB's continued commitment to both Henderson and the partnership, to talk through the findings of the independent reviews, and seek community support for continued effort to restore the island. One-on-one discussions were held with every adult member of the community present bar one, and a community meeting at the end of the visit secured unanimous support for work to continue to restore Henderson (RSPB unpubl.). A separate team visited Henderson to study the rat population's recovery, observe endemic bird numbers, and install a weather monitor. In particular, there was a concern that a booming rat population could overshoot pre-operational levels and pose a heightened threat to the 4 endemic landbirds. At that time, rat population was approximately one-third of the pre-operational level (RSPB unpubl.). There was no evidence of immediate threat to the endemic landbird species (Harrison 2012).

In order to address some of the questions raised by the independent reviews, an expedition to Henderson took place from June to September 2013. At that time, overall rat numbers were found to be approaching pre-operational levels (RSPB unpubl.).

DISCUSSION / CONCLUSIONS

The Henderson Island Restoration Project and the partnership with Island Conservation and Eco-Oceania Pty Ltd. demonstrated that aerial eradications can be conducted from the deck of a ship. This partnership also demonstrated that multiple island eradications can be carried out cost-efficiently together, a major precedent for the many remote islands of the Pacific region. Although projects of this scale are challenging, organisations that do not have a track record should not be afraid to take them on.

During the course of this operation, both the feasibility study and operational plan were independently reviewed. Additional management measures included meeting with the IEAG during the planning phase; a pre-operation readiness check with IEAG and Island Conservation; a post operation internal review before knowing the outcome; and three external reviews following confirmation that rats had persisted on the island. For the RSPB, involving experts and external organisations; allowing sufficient time for review; adaptive management; and making sure corners were not cut due to cost restrictions

provided the best opportunity to raise the required funding and optimise the chance of a successful outcome. Although the Henderson Island operation failed, the RSPB was able to successfully demonstrate to funders and the community of international eradication practitioners that best practice was followed and the failure was not due to inadequate management. This is viewed as a crucial factor in allowing us to investigate a second attempt on Henderson Island. Small scale and large scale operations should endeavour to follow a broadly similar approach.

A transparent approach to risk was also very important. Ensuring partners and funders are aware of the risk of failure in eradication attempts, as well as making the non-target risks transparent, is vital in avoiding negative backlash if things go wrong and in enabling second attempts where needed. A significant lesson from this operation is that there is a need to identify cost-effective strategies to help overcome unexpected weather and site conditions that could not have been predicted during the feasibility phase of the projects. Future small scale and large scale island restoration projects should incorporate this into their planning processes and project risk assessments.

During this operation, the team relied on their contacts with eradication experts built up over time to access information on similar past projects. However, it is recognised that there are inherent risks with this approach, with staff moving on from roles or organisational changes. Continuity is important for the eradication community. Projects should endeavour to publish in peer-reviewed journals or make technical information publically available through other means.

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