

Eradicating Pacific rats (*Rattus exulans*) from Nu'utele and Nu'ulua Islands, Samoa – some of the challenges of operating in the tropical Pacific

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Abstract The restoration of the small offshore islands of Nu'utele (108ha) and Nu'ulua (25ha) has long been identified as a priority for biodiversity conservation in Samoa. The first step towards restoration was the aerial spreading of brodifacoum to eradicate Pacific rats (*Rattus exulans*) in August 2009. Procedures for the eradication followed those used in New Zealand and involved technical experts from that country. Particular challenges included a tight operational time-frame (two months), technical problems magnified by the remote location, variable reliability of weather forecasting, working with the local community, and mitigating rodenticide exposure risks for the friendly ground-dove (*Gallicolumba stairi*) (IUCN: vulnerable). Solutions to these challenges are discussed as guidance for similar projects in remote island locations. Follow-up monitoring between August 2009 and March 2010 indicated that the eradication had been successful, but Pacific rats were detected on Nu'utele in May 2011. Nu'ulua has yet to be rechecked in 2011. DNA analyses are being organised to determine if these rats are survivors or re-invaders.

Keywords: Friendly ground-dove, helicopter bait spread, rodenticide, brodifacoum, communities

INTRODUCTION

The uninhabited islands of Nu'utele (108 ha) and Nu'ulua (25 ha) are in the Aleipata group 1.3 km off the eastern end of Upolu Island, Samoa (Fig. 1). The islands have long been identified as key sites for conservation (Park *et al.* 1992). They hold populations of the friendly ground-dove, tooth-billed pigeon (*Didunculus strigirostris*), coconut crabs (*Birgus latro*), nesting hawksbill turtles (*Eretmochelys imbricata*), and nesting seabirds including red-footed booby (*Sula sula*), brown booby (*S. leucogaster*), brown noddy (*Anous stolidus*), white tern (*Gygis alba*), and great frigatebird (*Fregata minor*). Along with Namua (20 ha) and Fanuatapu (15 ha), the four Aleipata islands have eight plant species and two vegetation communities that are rare on the main islands of Upolu and Savai'i (Whistler 1984). Furthermore, Nu'utele and Nu'ulua are the only uninhabited islands large enough and far enough offshore to be considered as refuges for native species that are threatened by introduced rodents. The islands could thus play a key role in sustaining Samoan biodiversity.

There were no published records of mammals of the islands until Pacific rats (*Rattus exulans*) were trapped on Nu'utele in 1991 (Park *et al.* 1992) and Nu'ulua in 2004 (Parrish *et al.* 2004). No ship rats (*R. rattus*) or Norway rats (*R. norvegicus*) have been observed or trapped on the islands though both are on Upolu. Three field-based studies in temperate areas concluded that ship rats and Norway rats can colonise islands up to 1km offshore (Russell *et al.* 2008). The absence of Norway and ship rats from Nu'utele and Nu'ulua suggests that they are unlikely to reach the islands by swimming. Pacific rats are not recorded to swim distances greater than 100m (Atkinson 1986).

Pacific rats have probably eliminated burrow-nesting seabirds on the Aleipata islands and probably have negative effects on many of the native species still present. When Pacific rats were removed from islands in New Zealand, there were benefits for vegetation (Campbell and Atkinson 1999) and populations of birds (Pierce 2002), reptiles (Towns 1991), and invertebrates (Green *et al.* 2011). One of the aims of our project was to determine the benefits of rat removals in Samoa to encourage further eradications of rats from islands in the region.

The islands are in the communal ownership of the local people and form part of the Aleipata Marine Protected Area (MPA), established in 2004, and to which 11 villages are

signatories. Restoration of the islands has been agreed to by the Aleipata District Community as one of the objectives in the MPA management plan and they have been involved in the development of the project since the outset.

In this paper we describe the methods used to plan and implement the eradication of Pacific rats from the Aleipata islands; outline the challenges faced by such projects in

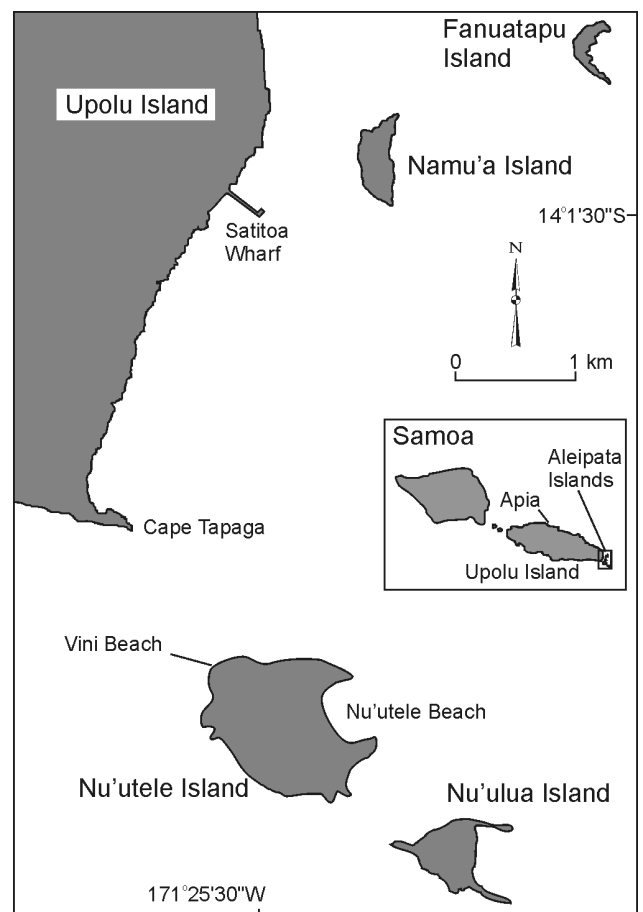


Fig. 1 Location of Nu'utele and Nu'ulua islands showing sites referred to in text.

relatively remote tropical locations; describe the outcomes achieved; and discuss biosecurity procedures and the implications of the re-detection of rats on Nu'utele.

METHODS

Project history

The feasibility of eradicating Pacific rats from Nu'utele and Nu'ulua was first investigated in 2000. Detailed planning for the project started in 2006 with a grant to the Secretariat of the Pacific Regional Environment Programme (SPREP) from the Critical Ecosystem Partnership Fund (CEPF) through the Regional Natural Heritage Programme. At one point, the eradication was scheduled for the same year, but was postponed when there proved to be insufficient time to complete operational arrangements.

An Environmental Impact Assessment (EIA), developed for the Government of Samoa and the Aleipata District community in 2006, identified one threatened taxon at risk of poisoning: the Samoan subspecies of the friendly ground-dove (*Gallicolumba s. stairi*). Nu'utele and Nu'ulua islands are the last strongholds of this subspecies in Samoa and are crucial to its survival. The birds feed on seeds and fruit on the ground, which exposes them to the risk of poisoning if they consume fragments of rat bait. We undertook to protect the population by holding birds from Nu'utele in temporary captivity. No ground-doves were taken from Nu'ulua because of difficult access and also because ground-doves could be reintroduced there from the re-established population on Nu'utele if required. Temporary aviaries were set up at the Samoan National Parks & Reserves headquarters at Vailima near Apia.

The project was implemented by SPREP, with Tye as project manager and Butler as project advisor, in partnership with the Division of Environment & Conservation, Ministry of Natural Resources & Environment (MNRE), Samoa (Assistant CEO: Tipama'a). Planning for the project was scrutinised by the New Zealand Department of Conservation (DOC) Islands Eradication Advisory Group (IEAG), who reviewed its operational plan, and an experienced DOC staff member (Wylie) was provided as the Aerial Drop Adviser for the aerial operation. The project was supported technically by the Pacific Invasives Initiative (PII), which adopted it as a 'demonstration project' for the region. Wellington and Auckland Zoos and an individual volunteer assisted with the ground-dove captive holding operation.

Rat eradication

Eradication methodology was based on successful operations in New Zealand and other island groups using Pestoff Rodent Bait 20R 10 mm extruded baits containing 20 ppm brodifacoum (Animal Control Products, Wanganui, New Zealand). Baits were dyed green, contained no bitrex, and were supplied in 25 kg bags with 40 bags to a pallet making an overall weight of 1050 kg per pallet. Pallets were shrink-wrapped and shipped from New Zealand in a container with black plastic fixed internally to the roof to reduce condensation. The container was transported to near the helicopter loading site and bags of bait transported to the bucket on the back of a utility vehicle.

Baits were spread using a spreader bucket slung below a Robinson R44 helicopter flown by North Shore Helicopters (NSH). Six tonnes were ordered to cover two planned drops at 10-day intervals on each island plus 1.5 tonnes for contingency bait application. Bait drops were planned for periods when weather forecasts predicted at

least three nights without rain, to ensure optimal exposure of the baits to rats. Flight lines were checked using digital GPS (TracMap).

Rats were trapped on both islands shortly before the operation and 19 tails samples collected from Nu'ulua and 7 from Nu'utele. These would be used for DNA analysis in the event that rats were found on the islands after the operation.

Ground-dove capture

Two expeditions to Nu'utele in 2006 developed capture and handling techniques for ground-doves. During the first field trip, attempts were made with a line of people to 'herd' birds into mist nets. This technique has worked elsewhere in the Pacific, but proved unproductive on Nu'utele, where the only ground-dove seen was not caught. The second trip used teams of two-three people, who quietly set up nets and left them for several hours. This group had over 20 encounters with birds. Although only one ground-dove was caught, the high encounter rate confirmed the potential efficacy of this technique.

Ground-doves needed to be caught as close to the time of rat baiting as possible to minimise the time birds were in captivity, yet the capture process could not hold up the spread of baits. Captures were scheduled for two weeks with a further week before the scheduled first spread of baits. However, delays meant that the intervening week was lost and captures of ground-doves began two weeks before the first bait drop.

A target of 10-12 birds was identified from assessments of their population on Nu'utele and the likely ease of capture. Once this number was captured, the rat baiting would proceed. A failure to capture this number would require re-assessment.

Two periods of netting were undertaken on Nu'utele on 21-23 and 27-30 July at Vini and Nu'utele beach flats (Fig. 1). The nets were visited every 1 – 1½ hours and birds were removed. The nets at Vini were left set overnight. Nets that required greater travel distances were shut down each evening. Three teams of 2-3 people worked with several nets, most of which were 60 mm mesh size (two were 40 mm). Ground-doves were transported to the campsite at Vini in cloth carry-bags and placed into small holding cages made of nursery shade-cloth. The birds were weighed and those captured on the second visit were banded. The birds were held in the cages for up to two nights before transfer by boat and car to Vailima.

Holding aviaries were built from shade cloth within a rat-proof area contained by welded wire mesh. Birds were housed as groups of two or three of the same sex and fed a Topflite seed mix for doves imported from New Zealand and containing white and Japanese millet, buckwheat, and sorghum. Twice each week, the birds were given the vitamin and mineral supplement Ornithon in their water (see also McCulloch and Collen 2009).

The survival of ground-doves left on the island would be assessed by the frequency of sightings of banded and un-banded birds after the operation.

Monitoring outcomes

Monitoring established to measure the outcomes of removing the rats included bird counts in July 2009 on a transect on Nu'utele and repeated in 2010, and lizard surveys on both islands in June 2009, December 2009 and August 2010. Photo points were also established.

RESULTS

Rat eradication

The first baits were spread on 15 August 2009. The second application of baits began on 22 August but was abandoned due to equipment failure after 80 ha of Nu'utele had been covered. This partial application was also compromised by subsequent rain. The final complete application of baits was on 26 August. The average application rate for the first drop was 12.5 kg/ha with coastal areas on both islands receiving a further 10 kg/ha. During the second, partial application 80 ha of Nu'utele (south-eastern c.76% of the island) received 8.3 kg/ha. The final average application rate on Nu'utele was 7.6kg/ha with an extra c.10.6kg/ha on the coastal areas and on Nu'ulua the rate was 11.6kg/ha. A cave at the base of cliffs on Nu'utele was hand-baited because it could not be reached from the air.

Ground-dove rescue

Twenty-six ground-doves, comprising nine adult males, one juvenile male, 15 adult females and one juvenile female, were taken into captivity. Four birds came from Nu'utele Beach, one from the hill track and the remaining 21 were from Vini Beach (Fig. 1). One net that was set on flat ground near the middle of Vini Beach, and adjacent to the base of the hill, caught 15 ground-doves.

Three ground-doves died in captivity, all in the first few days after transfer, and one was euthanased after a banding mishap. Twenty-two ground-doves were released on Nu'utele on 17 September, 22 days after the last drop. The released ground-doves were in good health after 49-56 days in captivity.

CHALLENGES

Prior to the operation

Issues with funding and project management structure

CEPF funding for the project was approved on 27 April 2009, but the funds were not received by SPREP until 2 June, only two months before the first scheduled poison drop. Since payments could not be made for baits and shipping until the funds were released, the project came within a few days of failing to meet the bait manufacturer's delivery deadlines.

Funding criteria and the history of local staff association with the project produced a problematic project management structure. SPREP managed the project as the Samoan Government were not eligible to receive the funding, but their project manager and adviser were unable to work on the project full time. In addition, between 2004 and 2009, five people were responsible for managing the Samoan Government's input to the project, including three changes to the Project Manager within MNRE during the ten weeks before the first drop. One departing manager had received significant training for rat and ground-dove aspects of the project. Another officer involved with the project since 2005 was transferred to a different section within the Ministry three weeks before the drop and was not able to be involved. The lack of full-time project management, together with these changes in Government personnel, made it very hard to maintain project momentum and ensure that tasks were completed on schedule. SPREP and DOC participants then had to take on management roles outside their advisory functions.

Helicopter contract and loading site

For several months before the operation, negotiations were held with an apparently suitable helicopter company

after signing the contract. They had undertaken similar drops in Fiji, received training from a New Zealand pilot highly experienced in island eradications, held a licence to operate in Samoa and offered a price well below budget as costs could be shared with other work scheduled in the country. In late June the company advised that their helicopter needed overhaul and would not be available until October, too late for the operational window of June-September. A second company, NSH in New Zealand, was in the process of gaining a licence to operate in Samoa and provided a competitive quote. After delays while a third quote was obtained to meet the donor's requirements, approval to use NSH was finally received on 18 July. A contract was signed on 23 July, leaving little lead-in time before the first spread of baits due in the week beginning 3 August. The company was selected partly because they had an experienced pilot and back-up person who had also worked with spreader buckets.

As planning progressed, the loading site at Satitua wharf on Upolu had to be changed after redevelopment made the previously identified one unsuitable. The Samoa Port Authority made an alternative loading site available.

During the operation

Weather forecasting

The operation was planned for early August - the middle of the 'dry' season - to minimise the chance of rain. The dry season of 2009 was wetter than normal in response to an El Niño event. Combined with forecasts of limited reliability for the local area, identifying a period with little chance of rainfall (<10mm total) over three nights became a challenge.

We used forecasting information supplied by the Samoa Meteorology Division, MNRE, the Fiji Meteorological Service, the Weather Service Office at Pago-Pago, American Samoa, and international web-sites offering long-range forecasts for Apia, particularly www.weather-forecast.com/locations/Apia/forecasts/latest because it estimated rainfall amounts.

The Meteorology Division provided specific 7-day forecasts twice a day for rainfall and wind speed at Nu'utele through a NOAA system, which estimates weather conditions for any location based on a Latitude/Longitude reference. However, these rainfall forecasts proved to be inaccurate. The Meteorology Division also provided links to weather satellite images and maps from the Australian Meteorological Service showing predicted rainfall patterns over a short time period. An automatic weather station at Cape Tapaga (Fig. 1) provided records of rainfall after each bait drop.

The first bait drop was scheduled for 12 August but was postponed when up to 100 mm of rain was forecast over the following two days. Although rain continued to be forecast over the next two days none fell. Based on predictions for improving weather (3mm of rain on the 15th), followed by deterioration after 18 August (>30mm over 3 days), the first drop was re-scheduled for 15 August. Following the first drop, 6.25 mm of rain was recorded between midnight and 10 am and the next two nights were dry. These conditions met the <10mm criterion.

Forecasts before the second drop predicted 0.1 mm of rain on the third day following. However 100mm fell over the next three days and nights so this drop would have been ineffective if it had been completed.

The final drop followed a suitable weather forecast after which there were five nights with negligible rain. However, both completed drops were undertaken in windy conditions, the first having occasional gusts of up to 25 knots. Nonetheless, flight lines downloaded from the GPS indicated that these conditions should not have affected bait coverage.

Helicopter operation including equipment testing and calibration

Because of tight timeframes after signing the contractor, there was insufficient time to calibrate the spreader bucket with non-toxic bait. NSH advised that the bucket had been tested many times for previous operations and that all aperture settings were already recorded. However, although the pilot and bucket were sourced from one company, the helicopter and GPS system originated from another.

The equipment expected in Apia on 6 August was further delayed when the freighter was diverted to another port en route and did not arrive in Apia until Saturday 8 August. The port does not operate on Sundays, and Monday was a public holiday so nothing was unloaded until 11 August. The helicopter and GPS system were tested on the 13 August and the spreader bucket was also tested, although unattached to the aircraft.

The delays meant that the agreed pilot and back-up both returned to New Zealand and were replaced by a new pilot with agricultural flying experience, but less familiarity with the GPS and spreader bucket systems.

Technical issues encountered during the first drop were: 1) an incorrect shackle attachment between the bucket and the helicopter had to be replaced as it had been set up for a different model; 2) the light panel on the TracMap navigation system that provides the pilot with course information stopped working; 3) the bait spread adjustment aperture at the base of the bucket closed itself during flight, was fixed with tape and cable ties, but had to be checked every time the pilot landed; 4) after the fourth load, the bucket spinner engine needed re-fuelling after unexpectedly heavy fuel use, jammed on re-starting, needed to be disassembled, would then only run with the air filter removed, and this further increased fuel consumption and the need for re-filling; 5) the TracMap flashdrive was left in Apia so it was not possible to download flight lines, check for gaps, and re-fly them at the time; and 6) a day after the drop, a patch on the cliff side of Nu'utele Island was found to have been left un-baited. The area would have been re-flown during the first drop had it been possible to monitor bait application, but was covered in the subsequent drops.

The bucket continued to give problems until the engine finally seized part way through the second drop. A replacement engine was flown from New Zealand for the third drop.

SUCCESSSES

Baits

Bait transfer and storage were not beset by problems. We followed ACP recommendations and every few days opened the bait container door during the day (if fine) and closed it at night. The shrink wrap was left on the pallets until the first drop as there was no sign of condensation and the bags remained moisture-free while in storage.

Liaison with local communities

One family was recognised by local communities as the main users/owners of Nu'utele where they maintained

two *fale* (open huts) and occasionally worked a small plantation of bananas or taro. Nu'ulua is not used by any families due to the difficulty of access. However, the whole district had an interest in events on the islands and the project maintained close liaison with the MPA District Committee.

The community was first asked to support the concept of rat eradication in 2000 and was involved in all subsequent project discussions. The community was then asked to re-endorse the project as it progressed and as difficulties arose. Liaison with the community was largely undertaken by the marine section of MNRE and the community remained supportive throughout. During implementation, members of the MPA District Committee observed the bait drops and villagers were employed to load the bucket with bait. Continuing community discussions are planned including debriefs for the MPA District Committee, an education programme for local schools, and further biosecurity training and implementation.

Health and Safety

On the morning of the first bait drop, the pilot and one of us (Wylie) provided a safety briefing for the villagers employed to load the bucket with MNRE staff providing translation into Samoan. The briefing was complicated by the pilot's unfamiliarity with the site and lack of briefing about how bait loading would proceed. However, the loading crew functioned well throughout and wore all protective clothing supplied, despite the very hot conditions.

The operation was safely observed by staff from MNRE, other conservation agencies, members of the MPA committee and other interested individuals.

OUTCOMES

Pacific rats

Nu'utele Island has been visited at least eight times since the spread of rat baits and Nu'ulua twice.

Both islands were visited in December 2009 and August 2010 during surveys to assess changes in lizard populations. Four-person teams undertook day and night surveys and set out 500 glue traps on each visit at a variety of locations. No glue traps had rat hair compared with 75% of traps showing evidence of rats in a pre-operational lizard survey in June 2009 (R. Fisher, unpublished data). However one of December's team subsequently reported seeing a rat at Vini Beach. This was partly discounted as it was not reported at the time, though two lines of traps were set up there in February 2010 and caught nothing.

A specific survey for rats was carried out on Nu'utele in March 2010. Poor weather prevented access to Nu'ulua. Kill traps, cage traps, bait stations, wax tags and tracking tunnels were deployed for a week on grids or transects covering different parts of the island. Fallen fruit was checked for any signs of chewing. No rats or rat sign were detected.

In late 2010, teams studying the invasive yellow crazy ant (*Anoplolepis gracilipes*) on Nu'utele recorded no rats. However in May 2011 one of these teams saw a rat on Nu'utele towards the top of the climb up from Vini beach. A follow-up survey in July caught 8 Pacific rats in this area and two at the northern end of Vini Beach. A brief trapping session on the coast of Upolu opposite the islands caught one Pacific rat, three Norway rats and two ship rats.

Friendly ground-doves and other native biodiversity

Within the first few weeks after the spread of baits, at least six ground-doves were seen on Nu'ulua and banded (released) and un-banded birds were seen on Nu'utele. These observations show that some of the ground-doves on both islands survived the poison drops. All subsequent expeditions to Nu'utele have reported greater frequencies of ground-dove sightings than before the operation.

The monitoring programme, which includes 5-minute bird counts, photo points, and lizard surveys, is continuing and results are not yet available. However quite dramatic increases in the ground cover of seedlings is apparent in many areas of Nu'utele.

BIOSECURITY

Biosecurity training to prevent rats reaching the islands was organised by PII in New Zealand, and attended by the Assistant CEO, MNRE, with overall responsibility for ongoing Government participation in the MPA, a representative of the family that use Nu'utele, and by two members of the MPA Committee. This training was cut short due to a tsunami affecting Samoa and completed in February 2010.

The tsunami reduced the risk of rats being accidentally taken back to the islands by boat for it damaged the nearest wharf and destroyed most fishing boats in the district. However, it could have increased the risk of an incursion through rats 'rafting' to the islands on debris which reached Nu'utele from Upolu.

For over a year after the operation, the MPA Committee inspected the equipment and supplies of all expeditions visiting the islands but this practice lapsed by mid-2011. Traps and bait stations have been placed on Vini and Nu'utele beach flats, Nu'utele Island and on the only beach flat on Nu'ulua Island, but not visited and re-baited as often as desirable.

DISCUSSION

The spreading of a prescribed amount of rodenticide bait was eventually achieved on both islands. However the subsequent detection of rats on Nu'utele is clearly a significant setback. There is little to be gained from speculation about whether these are survivors or re-invaders and it is hoped that this question can be answered shortly from DNA analyses. If the initial eradication did fail it is clear that this was not a widespread failure and much of Nu'utele is considered to have been free of rats up to now.

It was not possible to reach Nu'ulua during either the March 2010 or July 2011 rat surveys so the current situation there is unknown. Efforts are currently being made to reach the island using helicopters which are temporarily stationed in Samoa for filming.

The number of ground-doves captured before the baiting operation exceeded our expectations. The efforts of overseas experts and local staff ensured that ground-dove mortalities were restricted to four birds, which is not exceptional for a programme of this kind. Much was also learned about keeping this species in captivity. Biometric data and DNA samples collected from each captured bird will prove valuable to future conservation efforts.

Despite considerable planning effort, many last-minute problems with the rat eradication campaign could

have jeopardised its success. Most such issues were not completely unexpected, but some were exacerbated by the short period between the receipt of funding and the operation. Funders and project planners may need to allow for the long lead-in time required for such operations.

The turnover of Government staff involved in the project is not unusual in the Pacific, although the changes immediately before the operation were exceptional. Ideally, the same Government official would have a key management role throughout the eradication project and then supervised the subsequent biosecurity and restoration work. This situation may be unlikely in Small Island Developing States. In our project, some continuity was provided through the involvement of one of the owners of the island (a former MNRE staff person) and the project management team.

Weather forecasting can also be problematical in small island countries. The best strategy is to choose times of year with minimal rainfall and to purchase enough bait to do additional drops if the first ones are washed out.

An open tender process might be the best approach for helicopter support, but was unachievable for the Aleipata project. Pilot experience also requires consideration, and ideally should be made a contractual requirement. Obtaining such agreements may be difficult in remote locations, particularly if schedules may be uncertain.

Some of the technical problems associated with the helicopter might have been avoided if more time had been available for testing, especially since spreader buckets are a 'weak link' that has generated problems elsewhere (D. Merton pers. comm.). Ideally, two buckets should be on site, but this was not possible in Samoa because of cost and problems of availability. Where a second bucket cannot be provided, a good range of spare parts must be held, including if possible a spare engine to drive the spinner.

A biosecurity programme should be in place before an eradication proceeds. In this case, the two months between securing the funds and carrying out the operation were fully spent organising the poison drops. Sufficient lead-in time should be planned to allow biosecurity measures to be completed beforehand.

Funding delays for the Aleipata project were sufficient to postpone it for another year. But cancellation two months out would have been a very hard call to make because of the years taken to put key elements in place, namely: funding, Government and community support, and overseas individuals and agencies with time and resources committed. Once the decision was made to proceed, commitments were immediately entered into for the purchase of bait and travel for advisers. This meant that any last minute postponement would have led to the loss of significant funds, credibility, and support.

Further discussion is needed on how to match the thorough planning and checking that are features of successful operations in larger countries with the situation in the Pacific where many challenges can arise. There is clearly a higher risk of failure operating in a remote location but what level of risk is acceptable? What is the appropriate balance between the use of outside experts - as a key way of minimising risk, and involving local staff - as a means of building local capacity?

However well-planned and structured a project is, there seems little doubt that the ultimate key to operational success is the combined skills and commitment of those on the ground.

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