RESTORATION OF NU'UTELE AND NU'ULUA ISLANDS (ALEIPATA GROUP), SAMOA,
through the management of introduced rats and ants

BIODIVERSITY CONSERVATION LESSONS LEARNED TECHNICAL SERIES

13

CONSERVATION INTERNATIONAL
Pacific Islands

BIODIVERSITY CONSERVATION LESSONS LEARNED TECHNICAL SERIES

13 Restoration of Nu'utele and Nu'ulua islands (Aleipata Group), Samoa, through the management of introduced rats and ants

Biodiversity Conservation Lessons Learned Technical Series is published by:

Critical Ecosystem Partnership Fund (CEPF) and Conservation International Pacific Islands Program (CI-Pacific)

PO Box 2035, Apia, Samoa
T: + 685 21593
E: cipacific@conservation.org
W: www.conservation.org

The Critical Ecosystem Partnership Fund is a joint initiative of l'Agence Française de Développement, Conservation International, the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank. A fundamental goal is to ensure civil society is engaged in biodiversity conservation.

Conservation International Pacific Islands Program. 2013. Biodiversity Conservation Lessons Learned Technical Series 13: Restoration of Nu'utele and Nu'ulua Islands (Aleipata Group), Samoa, through the management of introduced rats and ants.

Conservation International, Apia, Samoa

Authors: Alan Tye, David J. Butler

Design/Production: Joanne Aitken, The Little Design Company, www.thelittledesigncompany.com

Cover Photographs: Top: The southern half of Nu'ulua, from the southeast, with intact lowland forest on the interior crater slope; Bottom: The east side of Nu'ulua, with the difficult boat landing site just below the line of rocks at the top of the photo. © Alan Tye.

All photographs © Alan Tye unless otherwise credited.

Series Editor: Leilani Duffy, Conservation International Pacific Islands Program

Conservation International is a private, non-profit organization exempt from federal income tax under section 501c(3) of the Internal Revenue Code.

OUR MISSION

Building upon a strong foundation of science, partnership and field demonstration, Conservation International empowers societies to responsibly and sustainably care for nature for the well-being of humanity.

ISBN 978-982-9130-13-6

© 2013 Conservation International

All rights reserved.

This publication is available electronically from Conservation International's website: www.conservation.org or www.cepf.net

The Critical Ecosystem Partnership Fund is a joint initiative of l'Agence Française de Développement, Conservation International, the European Union, the Global Environment Facility, the Government of Japan, the MacArthur Foundation and the World Bank. A fundamental goal is to ensure civil society is engaged in biodiversity conservation.

ABOUT THE BIODIVERSITY CONSERVATION LESSONS LEARNED TECHNICAL SERIES

This document is part of a technical report series on conservation projects funded by the Critical Ecosystem Partnership Fund (CEPF) and the Conservation International Pacific Islands Program (CI-Pacific). The main purpose of this series is to disseminate project findings and successes to a broader audience of conservation professionals in the Pacific, along with interested members of the public and students. The reports are being prepared on an ad-hoc basis as projects are completed and written up.

In most cases the reports are composed of two parts, the first part is a detailed technical report on the project which gives details on the methodology used, the results and any recommendations. The second part is a brief project completion report written for the donor and focused on conservation impacts and lessons learned.

The CEPF fund in the Polynesia-Micronesia region was launched in September 2008 and will be active until 2013. It is being managed as a partnership between CI Pacific and CEPF. The purpose of the fund is to engage and build the capacity of non-governmental organizations to achieve terrestrial biodiversity conservation. The total grant envelope is approximately US$6 million, and focuses on three main elements: the prevention, control and eradication of invasive species in key biodiversity areas (KBAs); strengthening the conservation status and management of a prioritized set of 60 KBAs and building the awareness and participation of local leaders and community members in the implementation of threatened species recovery plans.

Since the launch of the fund, a number of calls for proposals have been completed for 14 eligible Pacific Island Countries and Territories (Samoa, Tonga, Kiribati, Fiji, Niue, Cook Islands, Palau, FSM, Marshall Islands, Tokelau Islands, French Polynesia, Wallis and Futuna, Eastern Island, Pitcairn and Tokelau). By late 2012 more than 90 projects in 13 countries and territories were being funded.

The Polynesia-Micronesia Biodiversity Hotspot is one of the most threatened of Earth's 34 biodiversity hotspots, with only 21 percent of the region's original vegetation remaining in pristine condition. The Hotspot faces a large number of severe threats including invasive species, alteration or destruction of native habitat and over exploitation of natural resources. The limited land area exacerbates these threats and to date there have been more recorded bird extinctions in this Hotspot than any other. In the future climate change is likely to become a major threat especially for low lying islands and atolls which could disappear completely.

For more information on the funding criteria and how to apply for a CEPF grant please visit:

- www.cepf.net/where_we_work/regions/asia_pacific/polynesia_micronesia/Pages/default.aspx
- www.cepf.net

For more information on Conservation International's work in the Pacific please visit:

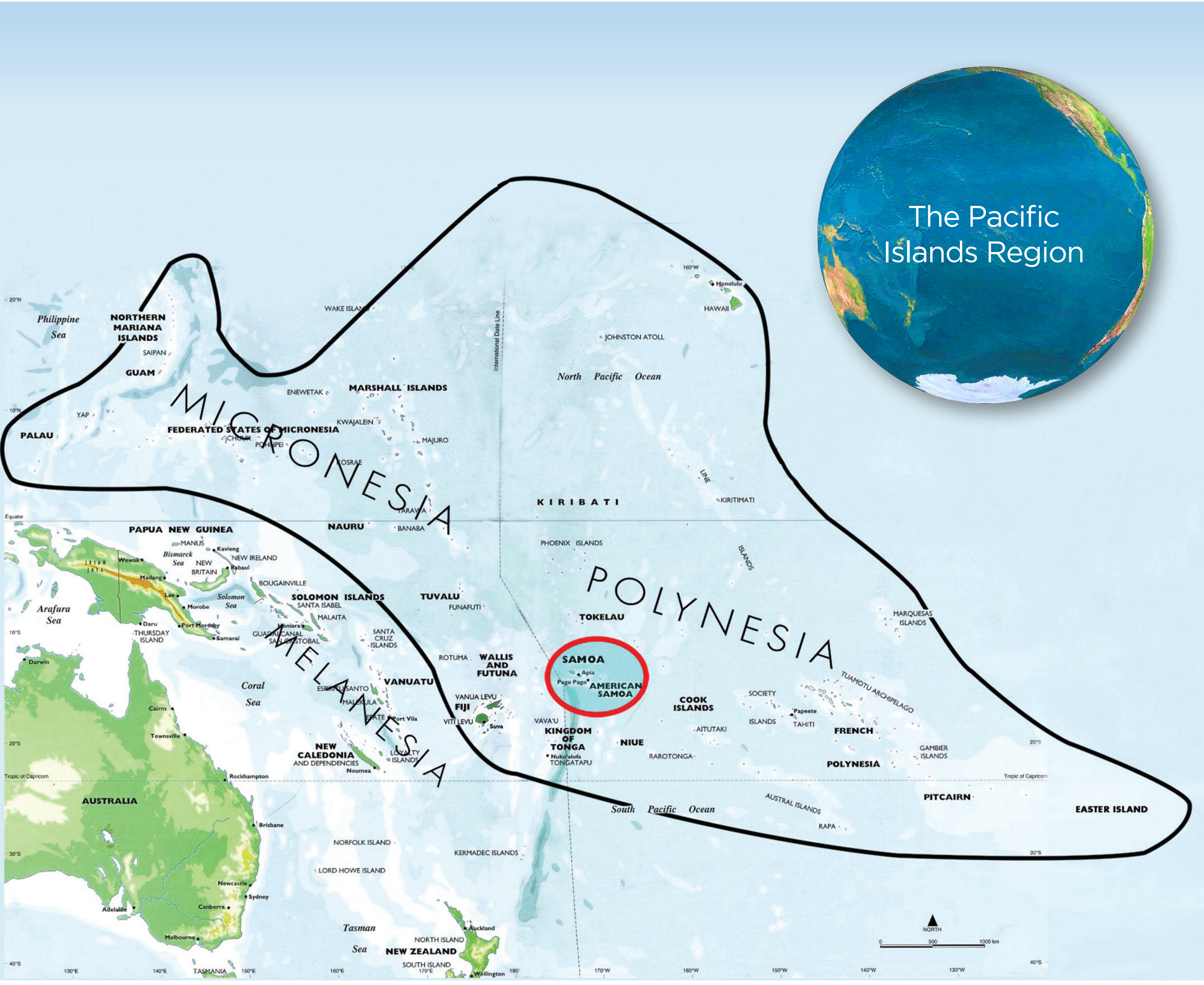
- www.conservation.org/explore/asia-pacific/pacific_islands/pages/overview.aspx

or e-mail us at cipacific@conservation.org

CRITICAL ECOSYSTEM PARTNERSHIP FUND

CONSERVATION INTERNATIONAL Pacific Islands

Location of the project in the Polynesia-Micronesia Biodiversity Hotspot



Contents

Lessons Learned

Project Design Process

Aspects of the project design that contributed to its success/shortcomings.

A major factor contributing to success was the recruitment of key advisors for several of the components, including an overall operations supervisor for Components 1, 2 and 4 (David Butler), an aerial operations advisor (Malcolm Wylie) and an expert on Yellow Crazy Ant (Ben Hoffmann).

Some of the project's activities were not achieved owing to lack of completion of commitments by other project staff and advisors. This applied to parts of Component 3 (monthly ant monitoring), Component 4 (reptile, bird and vegetation monitoring) and Component 6 (implementation and maintenance of biosecurity inspections, long-term monitoring and rapid response). Capacity loss due to staff turnover at the main government partner agency contributed to this. Further details on these points may be found in Butler et al. (2011).

Project Implementation

Aspects of the project execution that contributed to its success/shortcomings.

Based on our experience contracting a helicopter company, it is not sufficient to rely on one company that appears to be in a 'preferred supplier' position; a tender process should always be run to ensure back-ups in case situations change.

Based on experience with bait supply, if timing is tight, it would be worth drafting major supply contracts with suppliers at the point that funding looks assured rather than after it is approved. This would allow more time to address any conflicting issues.

A period of at least four months should be allowed between the confirmation of funding and an operation of the complexity of the rat eradication, to allow sufficient time for the process of tendering, testing equipment and assembling it on site.

Always build in at least one week's contingency for shipping delays and issues releasing and unloading cargo.

Butler et al. (2011) discussed the many changes in Government personnel involved in the project which meant that advisors and managers had to take a greater role than expected in project activities. Support from MNRE's Division of Environment and Conservation was not as strong as expected. In particular the Marine Section did not provide the boat support it was committed to, despite the project providing it with an outboard engine for its MPA work. MNRE Terrestrial Division was also unable to carry out other aspects of the project work, discussed above, owing to loss of capacity due to staff turnover during the period of the project. For further lessons learnt regarding the rat operation, see Butler et al. (2011).

Other lessons learned

relevant to the conservation community

Although the rat eradication on Nu'utele was followed by the detection of rats on the island, the temporary reduction of the rat population produced a valuable pulse of forest regeneration.

Figure 1. Coconut Crab on Nu'ulua Island.

Figure 2. The southern half of Nu'ulua, from the southeast, with intact lowland forest on the interior crater slope.

1 Background

This project was a key step towards a long-term goal of the restoration of Nu'utele (108 ha) and Nu'ulua (25 ha) islands, two of the four islands of the Aleipata group, off the eastern end of Upolu Island, Samoa. Nu'utele and Nu'ulua are major sites for the conservation of Samoa's indigenous biodiversity. They hold what are probably the largest remaining populations of the threatened (IUCN Vulnerable) Friendly Ground Dove *Gallicolumba stairi* in the Samoan archipelago, large populations of the Coconut Crab *Birgus latro* (Fig. 1), nesting Hawksbill Turtles *Eretmochelys imbricata*, and several species of breeding seabird. Nu'ulua also contains the most intact lowland coastal forest assemblage in Samoa (Fig. 2).

These are the only uninhabited islands in Samoa that are large enough and far enough offshore (Fig. 3) to be considered as potential refuges for several of the nation's species that are threatened by introduced mammalian pests. Threatened birds for which the islands could become a refuge include the Tooth-billed Pigeon *Didunculus strigirostris*, Ma'oma'o *Gymnomyza samoensis*, Island Thrush *Turdus poliocephalus* and Samoan White-eye *Zosterops samoensis*, while other organisms such as land-snails and native plants should also benefit from restoration. No burrow-nesting seabirds remained on the islands and it is likely that these were killed off by rats. They may return subsequent to rat eradication, or may require re-introduction or further intervention to encourage their re-colonization. The islands thus have the potential to play a key role in sustaining the future of Samoa's biodiversity.

The project was designed to address the threats to this ecosystem posed by two invasive alien species Pacific Rat *Rattus exulans* and Yellow Crazy Ant *Anoplolepis gracilipes*. Pacific Rat was probably a Polynesian introduction, or an accidental human-facilitated introduction from neighbouring Upolu. Yellow Crazy Ant had spread throughout Nu'ulua in recent years, threatening invertebrates, birds and reptiles, including turtle hatchlings, and could lead to irreversible vegetation changes. A small infestation was detected on Nu'utele in 2007 and its spread has been monitored since then, with some new sites detected but contractions or disappearance at others.

Both islands are customarily owned and involve at least four families or traditional titles from the villages of Aleipata District.

Figure 3. Nu'utele Island, as seen from the nearby shore of Upolu, shortest distance 1.3 km. Nu'ulua lies behind Nu'utele, 3.3 km from Upolu.

2 Project rationale

As a step towards island restoration, the project aimed to eradicate Pacific Rat from both islands through aerial delivery of baits from a helicopter. The project originally proposed to control or eradicate Yellow Crazy Ant by ground and aerial delivery of baits but, following expert advice, this objective was changed to obtain further information considered necessary for the design of a long-term management plan.

The local people who own and use the islands gave their support to the rat eradication as part of a larger, successful Aleipata Islands Marine Protected Area (MPA) project. The project thus involved working very closely with the community, through an MPA Committee involving representatives of all the villages in the District. Community members joined expeditions to the islands, were involved in the control operations and will have a key role in preventing pests from reaching the islands.

The project was designed as a demonstration project with the Pacific Invasives Initiative, and with the Pacific Invasives Learning Network facilitating the involvement of others from the region in the operation and the wide dissemination of its results.

SPREP signed a grant agreement with the Critical Ecosystem Partnership Fund on 1 May 2009 to deliver this project, with seven components:

1. **Eradication of Pacific Rat using aerial delivery of poison**
2. **Protection of Friendly Ground Dove from the poisoning operation**
3. **Management of Yellow Crazy Ant**
4. **Monitoring the response of the ecosystem to rat removal**
5. **Work with the local community to maintain support for the project and raise awareness of the need to protect the islands**
6. **Establishment of a biosecurity programme for the islands**
7. **Dissemination of results.**

1. Eradication of Pacific Rats

The feasibility of eradicating the Pacific Rat from the islands was initially investigated in 2000 (Bell 2000). Since then there have been a range of studies on the islands and feasibility assessments, carried out mainly by New Zealand scientists, including David Butler, who drafted an eradication proposal in 2003.

Detailed planning for the project was undertaken with a small grant to SPREP from CEPF through the Regional Natural Heritage Programme in 2006. New Zealand's Department of Conservation (DOC) provided Scott Hooson to develop an Environmental Impact Assessment (EIA) for both rat and ant management and an operational plan. The EIA was modified to cover the rat operation alone in 2008, and this was approved by the Aleipata District MPA Committee and the Government of Samoa, through its Planning and Urban Management Authority (PUMA). The Samoa Pesticides Board permitted the use of the rat toxin brodifacoum and the Civil Aviation Authority licensed the helicopter operation. The Operational Plan was developed by Malcolm Wylie, a DOC staff member highly experienced in aerial operations, again as part of DOC's in-kind support. The plan was updated in 2009 at the start of the present project. As part of the planning process, the Operational Plan was reviewed by the NZ DOC Island Eradication Advisory Group, a committee of people highly experienced with rat eradications.

The project adopted a proven technique developed in New Zealand and successfully used to eradicate rats from islands up to 12,000 ha, using brodifacoum anticoagulant baits made to precise specifications to maximize effectiveness and specificity, spread from a helicopter using differential GPS and a specialist pilot to ensure complete coverage.

Contracting a helicopter company to undertake the operation proved difficult. When the costing was undertaken for the CEPF proposal, a Fiji-based company was considered best placed to undertake the work. They had undertaken an aerial eradication operation in Fiji for Birdlife International and their pilot had been trained by an experienced New Zealand operator. They were licensed to fly in Samoa and potentially cost-effective as ferry charges could be shared with other work they had scheduled. A New Zealand-based company, Northshore Helicopters, keen to establish in Samoa, was also in contact with the project team.

Once funding was approved and the two companies were asked for a quote, the Fiji one was ruled out as it could no longer supply a suitable helicopter until October. By the time another quote was obtained to satisfy CEPF requirements, there was a very tight time-frame to finalise contracts with Northshore and arrange shipping of a helicopter and spreader bucket from New Zealand (Fig. 4). This time-frame was one factor behind subsequent difficulties with the aerial drops.

Figure 4. Robinson 44 helicopter, pilot Paul Trapski, with bait spreader bucket ready for loading, all supplied by Northshore Helicopters, New Zealand.

The boat carrying the equipment from New Zealand then made an unscheduled visit to American Samoa, delaying its arrival in Apia by several days. Its unloading was further delayed by a public holiday. This created problems for the helicopter reassembly by an engineer, flown specifically from New Zealand for this purpose, and reduced testing time.

Brodifacoum baits were supplied by Animal Control Products (ACP) in New Zealand. The company only manufactures these baits for a few months each year, so needed a confirmed order by early May to avoid a one-year delay. In this case the tight time-frame following approval of funding meant that we were only one week away from failing to meet the company's deadline for ordering and payment.

Shipment and storage of baits went smoothly under ACP's guidance. Six pallets of 20kg bags of bait (Fig. 5) were shipped in a container with a black condensation sheet hanging on the inside. While it was in storage in Samoa, every few days the door of the container was opened during the day and then closed again at night, to optimize storage conditions. Shrink wrap was left on the pallets until the operation, as there was no sign of condensation.

Figure 5. Brodifacoum bait awaiting loading, and in the spreader bucket.

The aerial operation took place over three days – 15, 22 and 26 August 2009 (Fig. 6). There were challenges with MNRE support, the operation of the helicopter and spreader bucket, and with weather forecasting. Two drops were scheduled. The first was completed successfully on 15 August, but the second drop, on 22 August, had to be abandoned part-way through treating Nu'utele, owing to failure of the spreader motor (Fig. 7). A new motor was flown from New Zealand and a replacement second drop was carried out successfully on 26 August.

Further details of the operation may be found in Wylie (2009) and Butler et al. (2011).

Figure 6. Helicopter heading from the operation site on Upolu to the islands, with loaded bait spreader. Nu'ulua is the further island in the centre of the photo, with Nu'utele to the right.

Figure 7. The bait spreader mechanism, with drive motor on the left.

Both islands were visited a few days after the operation in August 2009, to monitor rat sign and ecosystem effects. No rats or rat sign were detected on either island.

Both islands were visited in December 2009 by a team surveying reptile populations. The 4-person team 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. However, one team member subsequently reported seeing a rat at Vini Beach. Two lines of traps were set up there in February 2010, but caught nothing.

A specific survey for rats to Nu'utele took place in March 2010 (Butler 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.

Both islands were visited again in August 2010 by the team surveying reptile populations, using the same techniques as in December 2009. Once again no rat sign was detected.

In late 2010, the team studying the Yellow Crazy Ant on Nu'utele recorded no rats. However in May 2011 a member of this team saw a rat on Nu'utele towards the top of the climb up from Vini Beach. A specific survey in July caught eight Pacific Rats in that area and two at the northern end of Vini Beach (Butler 2011a). A brief trapping session on the coast of Upolu opposite the islands caught one Pacific Rat, three Norway Rats *Rattus norvegicus* and two Black Rats *Rattus rattus*.

Although rats are present now on Nu'utele, it is not clear whether these are survivors of the operation or re-invaders. It is unlikely that Pacific Rats would swim the distance from Upolu to Nu'utele, but the tsunami in September 2009, just after the eradication operation, washed up large quantities of debris on the island, on which rats could have floated. Samples were collected for DNA analysis to try to determine whether the rats now on the island are survivors or re-invaders, but these were lost by the courier company contracted to send them to the laboratory in Auckland. Further sampling took place in 2012.

Nu'ulua was surveyed for rats just after the rat operation, when helicopter assistance was available (Figs 8 and 9). It was then not possible to land on the island again until 2012, when a further survey found no sign of rats. It is therefore believed that the eradication succeeded on Nu'ulua, although one more check would be advisable for final confirmation.

2. Protection of Friendly Ground Doves

An EIA identified that the main threat from the rat operation was that Friendly Ground Doves might eat and be killed by the baits. The project thus included catching and removing birds from Nu'utele into temporary captivity near Apia on Upolu. The birds were re-released on the island on completion of the eradication.

Figure 8. The helicopter landing spot on Nu'ulua Island, used for dropping the monitoring team and equipment.

Figure 9. Landing on Nu'ulua by boat is difficult. Boats must approach between the offshore rock and the far peninsula, then land where the peninsula meets the beach. The prevalent swells from the east render this impossible most of the time.

Friendly Ground Doves are considered close to extinction on the two main islands of Upolu and Savai'i – a recent survey of the uplands of Savaii, considered a possible refuge, detected none (Atherton & Jefferies 2012) – so Nu'ulua and Nu'utele are considered to be the last stronghold of the Samoan subspecies. As a bird that feeds on the ground on fruit and seeds they were considered at risk from the grain-based pellets containing brodifacoum. Discussion among experts on the best approach resulted in a decision to move a group of birds from Nu'utele, the more accessible of the two islands, to temporary captivity on Upolu rather than try to protect them on the islands. Glen Holland, then Director of Auckland Zoo, was asked to assist with this work and David Butler carried out trial captures as part of planning for the operation. Dieter Rinke, who had previously kept the species in Tonga, Peter Luscombe of Honolulu Zoo, and Peva Levy who had kept the related Tuamotu Ground Dove in captivity, were involved in discussions on capture techniques, aviary design and captive management.

The project built aviaries at the Vailima Botanical Garden. Holland, Butler and Richard Parrish managed the capture of 26 doves on Nu'utele. The doves were managed in captivity for 49–56 days by Rose Collen and Bronwyn McCulloch. Three birds died during the course of the operation and the others were released on Nu'utele after a suitable period, to allow baits to disappear completely.

Birds left on both islands survived the operation: none was found dead on either island, and several live birds were seen on both islands a few days after it.

This operation was considered highly successful and much was learned about capturing and holding the species. This is valuable experience if similar work should be needed in the future, with this or related species.

Three unpublished reports (Parrish 2009, Collen et al. 2010, McCulloch & Collen 2010) and one published article (Collen et al. 2011) provide further detail on this operation.

3. Management of Yellow Crazy Ants

The project examined the biology and impacts of the populations of Yellow Crazy Ant in accessible areas of Nu'utele, to contribute to formulating a management plan.

Two studies carried out in 2006 by Abbott (2006) and Vanderwoude (2006) contributed to the design of this project. Yellow Crazy Ants were found to have spread throughout Nu'ulua and a small infestation was detected on Nu'utele in 2007. Night video recording on both islands had suggested that the ants' presence was associated with significant changes in invertebrate populations, as seen elsewhere in the world. The ants also threaten birds and reptiles including turtle hatchlings, and their activities could lead to irreversible vegetation changes.

Work in Australia and elsewhere has shown that it is possible to reduce the numbers of Yellow Crazy Ants by ground or aerial distribution of baits containing toxin or insect growth regulators. Baiting trials and invertebrate sampling were carried out on Nu'utele before the project, and a draft EIA and operational plan developed for a proposed toxic baiting programme. However, work to identify the ideal bait with minimal non-target impacts continues and, on the basis of expert advice from Dr Ben Hoffmann, it was considered premature to carry out ant management on Nu'utele and Nu'ulua before further information could be obtained on the ant populations and their impacts there, and on bait developments elsewhere.

Ant populations on the islands were monitored before and during the project, particularly on Nu'utele. Up to 2009, the species was found to have spread on Nu'utele, from its 2006 level of c. 8 ha, and with several new infestation sites found. However, surveys after 2009 showed that the main infestation at Nu'utele Bay had severely declined in extent, to c. 1 ha, perhaps partly as a result of the September 2009 tsunami, although ants had also disappeared from higher parts of the former infestation. Also, new infestation sites were discovered while others disappeared. In 2010 and 2011, the largest infestation appeared to be at the north side of Vini Beach (Fig. 10). The infestations in the western half of the island may represent separate introductions by boats from Upolu.

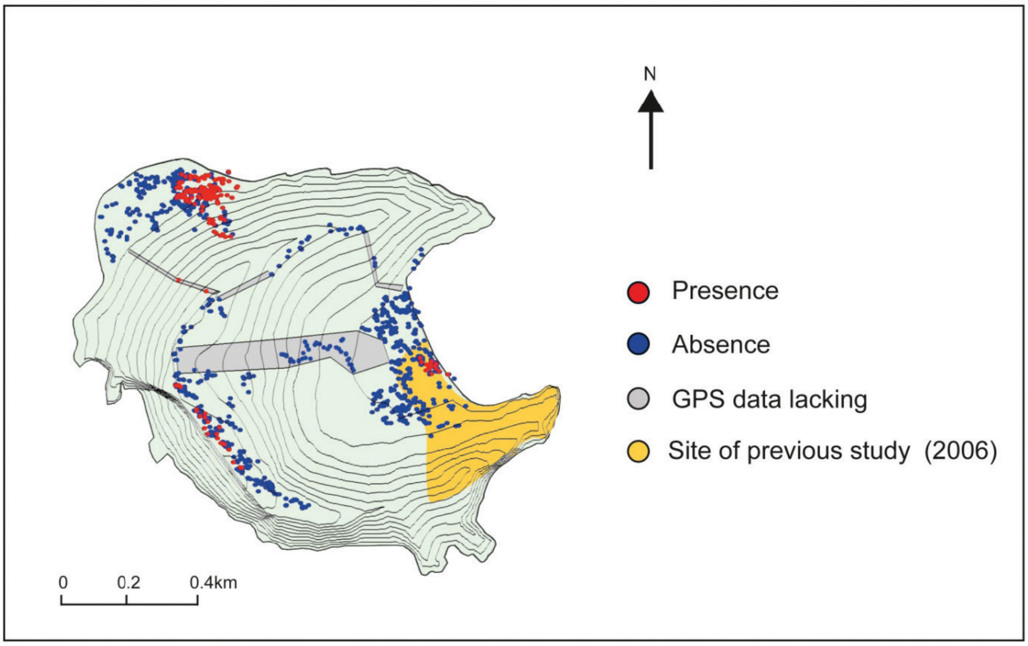


Figure 10. Infestations of Yellow Crazy Ant on Nu'utele Island in 2010, with 2006 infestion at Nu'utele Beach shaded yellow. Map from Auina (2011).

Details of the ant's reproductive cycle were obtained during visits to the island by Hoffmann and Saronna Auina in October 2010 and May 2011. This information is essential for determining the best timing for management actions, particularly when using growth regulators. However, further information on this is still required, based on monthly monitoring over at least a 12-month period. Monthly monitoring of Yellow Crazy Ant and invertebrates was to have been carried out during this project by MNRE staff, but this was unfortunately not done.

This study also gathered further information on impacts of the Yellow Crazy Ant, which was shown to affect the ant community composition. Native ant abundance was lower in areas with Yellow Crazy Ant although native ant species richness was higher in infested areas. Abundance and diversity of most invertebrate groups were not significantly affected by the presence of Yellow Crazy Ant. However, at least at one of the two visits, woodlice and Diptera were more common in infested sites, while spiders, Lepidoptera and hermit crabs were less common in infested areas. Some relationships between the ant, certain plant species with extra-floral nectaries, scale insects and mealy bugs were discovered, but their significance (if any) for management is not yet clear.

Further details of this work can be found in Auina (2011) and Hoffmann (2011).

4. Monitoring ecosystem response

Since the main objective of the project was to contribute to the restoration of the native ecosystem of the islands, monitoring was established to attempt to assess to what extent this objective was achieved following each intervention. This is envisaged as the establishment of a long-term monitoring programme on the islands, with a baseline set by monitoring various ecosystem components before the rat eradication operation, immediately after the operation, and at intervals thereafter (Fig. 11). So far, up to three monitoring phases have been completed, for different ecosystem components, as described below.

Reptiles. Robert Fisher was contracted from the US Geological Survey to carry out three surveys of reptiles on Nu'utele, Nu'ulua and the two other Aleipata Islands of Namu'a and Fanuatapu. The first survey was prior to the rat operation, the second soon afterwards (December 2009) to determine if the rat poison had any impact, and the third a year after it (August 2010) to determine any response from the planned removal of rats. This work (Fisher et al. 2012) has not revealed any impact of rats or their eradication on the reptile fauna but serves as a baseline for future monitoring.

Birds. Cedric Schuster was contracted to carry out bird surveys on Nu'utele before and a year after the rat operation, using 5-minute point counts. The results are of questionable value because at the post-operational survey only two days of surveying were possible, timing between the surveys was apparently inconsistent, and the sampling regime was sensitive enough to detect only very large population changes with any reliability. The results are presented in Schuster (2010).

Vegetation. Photo-points were established on Nu'utele and Nu'ulua before the operation but it has only been possible to repeat these on Nu'utele to date. Two locations have been lost due to a tree fall and the tsunami. The results of these and other observations suggest that a cohort of tree seedlings survived to reach sapling stage as a result of the rat population reduction. These saplings are now no longer vulnerable to rat damage and so should provide a pulse of forest regeneration. Before this project began, MNRE staff also established nine vegetation plots on Nu'utele, in 2007 (Foliga et al. 2007). As part of the present project, MNRE established similar plots on Nu'ulua in 2009. However, the Nu'utele plots have not been resurveyed, and the coordinates and results of the Nu'ulua recording were lost, so they cannot be repeated.

Invertebrates. The studies by Abbott (2006) and Vanderwoude et al. (2006) provided a partial baseline for invertebrate monitoring, although both of these studies were focused on ants. However, coordinates for their pre-operation sampling sites were lost, so these sites could not be re-sampled. The sticky traps used by Robert Fisher for reptile sampling provided information on invertebrates too (Fisher et al. 2012). Ben Hoffmann and Saronna Auina carried out invertebrate sampling as part of their work on Yellow Crazy Ant. These results are presented in Auina (2011) and Hoffmann (2011).

Figure 11. Landing for a monitoring visit, on Nu'utele Beach, east side of Nu'utele Island.

5. Community Relations

MNRE led the liaison with the MPA Committee who represented the communities, supported by project staff. MNRE passed to the communities the information needed to obtain their support for the aerial drop. Three of the MPA Committee observed the first drop, and members of the community were contracted as assistants (bait loaders etc.) during the drops.

Other initiatives planned with the community and local schools were put on hold when the tsunami devastated Aleipata District in September 2009. Life has slowly returned to normal, though many families have moved away from the coast. Some of the planned work that was unable to be completed because of the disruption could now be contemplated, although this will require new resources.

Community liaison and awareness benefited from activities associated with the detection and eventual eradication of a mongoose in the District. The response to this incursion was part-financed by another CEPF grant, and the two projects worked in parallel during 2010. Full details of this work are given in Fisher et al. (2011) and Tye et al. (2011).

6. Biosecurity

An essential part of any island eradication is an assessment of the probability of reinvasion by the pest which it is proposed to eradicate, and the introduction of means to reduce that probability, if considered advisable. The project planning phase evaluated the probabilities of rats reaching the islands by various means, and considered that they were low enough to recommend eradication, but that improving biosecurity was advised. As part of the restoration of the islands, it is essential also to prevent other invasive species from reaching them. The project therefore included a set of activities to improve biosecurity for the islands.

MNRE staff and the local communities of Aleipata District were to be trained in biosecurity and given the means to implement improved measures. This work included training (Baling & Nagle 2010), the development, production and use of biosecurity protocols and guides, and the implementation of a long-term monitoring and rapid response system.

The biosecurity training was scheduled to be run by PII in September 2009 in Auckland, and community and MNRE members were attending the course when the tsunami struck Samoa. The Samoan participants had to abandon the course and return to their families, and this workshop was eventually completed in Samoa in March 2010.

A biosecurity manual and visitors' guide (MNRE & Aleipata Islands MPA Committee 2012, MNRE et al. 2012) were developed by SPREP and PII, and submitted to MNRE for eventual publication and distribution.

A system to inspect boats, equipment and supplies taken by people visiting the islands was established by the MPA Committee and they undertook inspections through most of 2010. However, the system lapsed in 2011.

The tsunami was a possible cause of the rats now found on Nu'utele, as much debris was washed up on Vini Beach (see Figs 12 and 13). Lines of bait stations with wax baits and traps were set up on Vini Beach in January 2010 and on Nu'utele Beach in March 2010. Such devices have not yet been set up on Nu'ulua owing to problems of access. Nu'ulua can only be reached if seas are relatively calm and the consequent low rate of visitation by boats is one of its key defences against re-invasion by rats. It has not been possible for MNRE to establish regular monitoring or a rapid-response system for the islands. This should be a major concern for any future eradication plans, whether of rats or any other pest on the islands.

Figure 12. Ulutogia Women's Committee Centre, 22 November 2005 and 2 October 2009. Nu'utele and Nu'ulua are off the frame to the right. Photos courtesy of Petaia I'amafana.

Figure 13. Lalomanu looking east, 10 December 2005 and 2 October 2009. Nu'utele Island is visible on the right. Photos courtesy of Petaia I'amafana.

7. Dissemination of results

The three publications and 12 unpublished reports produced by this project to date are marked with asterisks in the References, below. Further publications are expected to be produced in the coming months, to place more of the results on the scientific record.

Periodic press releases were issued by SPREP to mark significant stages of the project, and articles stemming from them appeared in the Samoan media, including newspapers, radio and television.

The project was featured in the SPREP Annual Report for 2009 (Anon. 2010), and on the SPREP website. Periodic information briefings and reports were disseminated throughout Pacific invasives and conservation networks, in the *PILN Soundbites* and Pacific Invasives Initiative (PII) e-newsletters.

MNRE staff met periodically with the MPA Committee and local communities, to keep them informed of progress with the project.

The rat operation was the subject of a presentation at the international conference on *Island Invasives: Eradication and Management,* held in Auckland, February 2010.

It was planned to produce a short video on the project, but this proved impossible owing to capacity loss due to staff turnover at MNRE. Extensive footage of project activities was taken and remains available.

8. References

** indicates documents produced by this (CEPF-funded) project.*

PUBLISHED:

*Anon. (A. Tye) 2010. Saving Nu'utele and Nu'ulua Islands from rats. Pp. 28–29 *in* Secretariat of the Pacific Regional Environment Programme (ed.), *SPREP Annual Report: 2009*. SPREP, Apia.

*Atherton, J. and Jefferies, B. (editors) 2012, *Rapid biodiversity asssessment of upland Savai'i, Samoa*. SPREP, Apia.

*Butler, D.J., Tye, A., Wylie, M. & Tipama'a, F.T. 2011. Eradicating Pacific Rats (*Rattus exulans*) from Nu'utele and Nu'ulua Islands, Samoa – some of the challenges of operating in the tropical Pacific. Pp. 407-412 *in* Veitch, C.R., Clout, M.N. & Towns, D.R. (eds) *Island Invasives: Eradication and Management*. IUCN, Gland.

*Collen, R., McCulloch, B., Butler, D. & Holland, G. 2011. Captive care of Friendly Ground Doves. *Australian Birdkeeper* 24: 712–713.

Fisher, R., Uili, M., Iese, C., Evaimalo, N., Tipamaa, F.T., Bonin, M., Atherton, J. & Tye, A. 2011. Rapid response and eradication of an invading mongoose in Samoa. *Oryx* 45: 15–16.

UNPUBLISHED:

Abbot, K. 2006 *Delimiting Survey of a Yellow Crazy Ant Infestation, and Pre-treatment Monitoring Set-up on Nu'utele Island, Aleipata, Samoa*. Unpubl. Report to SPREP.

*Auina, S.S.A. 2011. *Impacts of* Anoplolepis gracilipes *(Yellow Crazy Ant) on Invertebrate Communities in Nu'utele, Samoa*. M.Sc. thesis, University of Auckland.

Baling, M. & Nagle, B. 2010. *Island Biosecurity Training for Nu'utele and Nu'ulua Islands (Aleipata Island Group), Apia, Samoa*. Unpubl. report to SPREP.

Bell, B.D. 2000. *Feasibility Survey on the Removal of Rats: Nu'utele and Nu'ulua Islands, Samoa*. Unpubl. report to SPREP.

*Butler, D.J. 2010. *Report to SPREP on Expedition to Check for Rats March 2010*. Unpubl. report to SPREP.

*Butler, D.J. 2011a. *Rodent Check of Nu'utele Island. 25 July to 3 August 2011*. Unpubl. report to SPREP.

*Butler, D.J. 2011b. *Restoration of Nu'utele and Nu'ulua Islands (Aleipata Group), Samoa, through the management of introduced rats and ants. Final Consultancy Report to SPREP.* Unpubl. report to SPREP.

*Collen, R., McCulloch, B., Butler, D.J. & Holland, G. 2010 *The Captive Care of Friendly Ground Doves in Samoa.* Unpubl. report to SPREP.

Fisher, R., Uili, M., Iese, C. & Enoka, F. 2012. *Reptiles of the Aleipata Islands. Report to the Secretariat of the Pacific Regional Environment Programme. Aleipata Islands Reptile Surveys 2009–2010*. Unpubl report to SPREP.

Foliga, T., Siolo, S. & Uili, M. 2007. *Report on the Biodiversity Monitoring Activity on Nu'utele Island, 6th-8th August 2007*. Unpubl. report, Ministry of Natural Resources & Environment, Samoa.

*Hoffmann, B. 2011. *The Status and Impacts of Yellow Crazy Ant (*Anoplolepis gracilipes*) on Nu'utele, Aleipata Islands, Samoa: Final Report.* Unpubl. report to SPREP.

*McCulloch, B & Collen, R. 2010. *The Captive Care of Friendly Ground Doves – Vailima Botanic Gardens, Apia 2009.* Unpubl. report to SPREP.

*MNRE & Aleipata Islands MPA Committee 2012. *Preserving the Islands of Nu'utele & Nu'ulua, Aleipata Islands, Samoa. Biosecurity manual*. Unpubl. draft submitted to MNRE.

*MNRE, Sagapolutele Family & Aleipata Islands MPA Committee 2012. *General Checklist for Travelling to Nu'utele and/or Nu'ulua Islands.* Unpubl. draft submitted to MNRE.

*Parrish, R.G. 2009. *Report on Friendly Ground Dove Capture Trip to Nu'utele Island July 2009.* Unpubl. report to SPREP.

*Schuster, C.T. 2010. *Bird Counts Report: Restoration of Nuutele and Nuulua Islands (Aleipata Group)*. Unpubl. report to SPREP.

Tye, A., Barun, A., Bonin, M., Evaimalo, N., Fisher, R., Gleeson, D., Iese, C., Tipama'a, T., Uili, M. 2011. *CEPF Small Grant Final Project Completion Report: Emergency Management of an Incursion of Mongoose on Upolu Island, Samoa*. Unpubl. report to CEPF.

Vanderwoude, C., Siolo, S., Sio, F. & Samani 2006. *Assessment of Yellow Crazy Ants (*Anoplolepis gracilipes*) on Nuulua Island, Aleipata, Samoa with recommendations for population control.* Unpubl. report to SPREP.

*Wylie, M. 2009. *Report on the Nuutele & Nuulua Island (Aleipata) Pacific Rat Eradication Project*. Unpubl. report to SPREP.

PART 1

APPENDIX 1

Reptiles of the Aleipata Islands

Report to the Secretariat of the Pacific Regional Environment Programme

Aleipata Islands Reptile Surveys 2009–2010

12 MAY 2012

Robert Fisher (USGS), Moeumu Uili (MNRE), Czarina Iese (MNRE), Fialelei Enoka (MNRE)

USGS
science for a changing world

1.0 Summary

The Aleipata Islands were surveyed for reptiles in 2009 and 2010 to monitor their response to the rat eradication program and to assess the yellow crazy ant impacts. A total of 12 reptile species were found including one invasive species. Three of these species are almost endemic to Samoa. Two lizard species previously unrecorded from the Aleipata Islands were detected, one is a native and the other an invasive species. The highest number of species (8) was detected on Nu'utele Island.

The design for the monitoring was straightforward, with before and after samples to be collected from the treatment islands. Namua Island was to serve as a control site with rats, and Fanuatapu Island was to serve as a control site with no rats. Unfortunately logistics were a bit more difficult and sampling was not quite able to be done following this design. Also, the tsunami tragedy that struck Samoa in 2009, also impacted these islands, with big changes to the beach vegetation on Nu'utele and Nu'ulua Islands from the salt water influx. This also had an impact on the distribution and abundance of yellow crazy ants at these sites where we had established monitoring locations.

An additional goal was to partner with MNRE on this project so that they would gain the expertise on terrestrial reptiles and techniques for monitoring these species. This goal was met through the field collaboration and training, development of the reptile reference collection, and the development of the reptile brochure.

A number of conservation recommendations based on the results of the survey are discussed including, identification of potential management actions to enhance the island diversity, and issues associated with the spread of invasive species.

2.0 Introduction

The restoration of tropical Pacific islands is a relatively new process. Most of the conservation targets for these projects are birds or plants. The exception is the crested iguana in Fiji, where restoration of Yadua Taba has been underway for about 30 years and the species has greatly recovered its populations on that island. There is an overall lack of knowledge about the biology and even systematics of many reptile species in the Pacific, which limits their consideration in the planning process (Fisher 2011). For lizards we know much more about their responses to rat eradication programs in the temperate regions and they have been found to respond rapidly to these actions, leading to important conservation of species (Towns et al. 2006). The Aleipata Islands restoration project presents a first opportunity to begin to study the response of tropical Pacific lizards to a rat eradication program.

We had several goals for this study. The first was to try to understand the response of the reptiles to the eradication of the rats from the two Aleipata Islands – Nu'ulua and Nu'utele (Butler et al. 2011). This included using Namua Island as a rat island (no eradication) and Fanuatapu Island as a rat free control. The next was to begin to study the interaction of yellow crazy ants and the native lizards on the islands, to determine if there is a potential impact. The third was to develop a more complete species list for the islands with the intent of publishing this fauna in the primary literature. The fourth was to work as a team (MNRE and USGS) to directly design and implement the study to ensure that knowledge transfer was done so that MNRE could better include reptiles in their planning and implementation of the Biodiversity Strategy and Action Plan. Lastly, we planned to create some outreach material for use by MNRE on the reptiles of Samoa.

2.1 Previous Reptile Records from the Aleipata Islands

Limited research on reptiles of Samoa has been done. Gill (1993) summarizes all of the knowledge to date. He includes his 1991 observations from Samoa, and the collections made by Fisher in 1988 and 1990 and housed at the California Academy of Sciences. In his summary, there were no known records for reptiles from the Aleipata Islands. In 1992 George Zug and Ivan Ineich conducted a further survey of Samoa, but again did not include any sampling in the Aleipata Islands. Beginning in 2000, several field projects were conducted on the islands that included surveys for reptiles (Springer et al. 2003a,b, Parrish et al. 2004) and they report the first records for these islands. Our surveys in 2009 and 2010 were the first to utilize sticky traps to further investigate this fauna.

3.0 Methods

The survey covered all four Aleipata Islands (Nu'utele, Nu'ulua, Namua, Fanuatapu). Unfortunately certain conditions made it not possible to sample every island every visit, but enough visits were done to each island to detect the main patterns seen in the reptiles (Table 1, p.38).

The survey effort on each island consisted of three techniques if possible (Fisher 2011), but constrained by weather and boat schedules. The techniques included:

1. **Day surveys** of the habitats around the island, as possible, with capture of animals by hand and counts of the individuals seen on each survey and the time the survey took.
2. **Sticky trap transects** that could be placed across various habitats represented on the island were set up (Figure 1). Each station consisted of three standard mouse traps, one placed on the ground, one placed on a log off of the ground, and the third one stapled to a tree (Figure 2). These traps were optimally placed out in the afternoon and then collected the next morning so that they would sample diurnal and nocturnal species. They also were used to detect rat and yellow crazy ant activity.
3. **Night transects**. These are the only effective way to collect data on boas and geckos and these were both time and distance constrained surveys. We also recorded any pig, coconut crab, and rat observations made during these surveys.

4.0 Results for Islands

The results for species by island are summarized on Table 2, and discussed by island below.

Fanuatapu

A good island-wide survey was conducted and it is believed that the four species detected are almost the entire list (Table 2). The island has a small fishing camp (fale) infrequently used at the very small beach. There are stairs up to the ridge where the lighthouse is located. We were able to conduct good daytime, night time, and sticky trap surveys on this island. Although we need to have one additional sticky trap survey there that was not done due to time lost from some boating issues in August of 2010. MNRE was going to conduct this follow-up survey but other priorities have kept this from being conducted. For the transects we were able to run the traps all the way across the ridge, along the small beach, and up the cement stairs.

Nactus pelagicus is possibly an additional species that occurs on Fanuatapu but we did not detect it during our survey. There are some very rocky slopes we could not feasibly sample that appear suitable for this species. Also we did not detect *Emoia impar* on the island, and it seems that intense predation pressure from *Emoia nigra* might be a limiting factor for it on the island. There were no previous records for reptiles from this island except in the Springer (2003a,d) and Parrish (2004) reports. These data can serve as baseline for future studies. Much of the island is still native vegetation, with plantation and disturbance just along the beach and stairs. The grassland habitat along the east side is a unique habitat in the islands. The main threat would be of invasions by house geckos (Hemidactylus frenatus), which could happen via the fishing boats travelling between Namua or Upolu and the island. Currently this threat is low as it seems that few people visit this island.

Surprisingly, this island appears both rat and yellow crazy ant free. These two species apparently have never invaded the site and a priority for conservation would be to put biosecurity signage on the island informing people about not moving materials around that might host propagules of these species.

Namua

We were able to conduct two good island-wide surveys for reptiles, although we could only put sticky traps on the ridgeline due to the disturbance from dogs, chickens and people along the beach. This island served as our "rat" control, as it was not treated for rat, but had rats during both survey events. We detected seven species on this island, five of which were previously detected by Parrish et al. (2004). They detected one species we did not detect, which was the *Lipinia noctua,* and we detected two that they did not detect, *Nactus pelagicus* which is a native species, and *Hemidactylus frenatus* (house gecko) which is an invasive. The house gecko is a bad invasive in the Pacific and was probably brought to Namua recently with the movement of materials for the development of the resort. It was only found on resort fales.

We found *Emoia impar* to be rare and only on the beach around the fales, and primarily *Emoia nigra* is the dominant species on the ridgeline. Rats were detected in the forest during night surveys and on the sticky traps. Yellow crazy ants were found but very rare on the island.

Currently the further development of gardens above the fales is removing native forest.

Nu'utele

This is the largest island in the group and has the greatest species diversity. We were able to conduct three good sets of surveys and one additional ridgeline sticky trap set. We conducted one good set of surveys before the rat eradication, and the other sets were conducted post eradication. We found the highest diversity on this island (nine species), one additional species than Parrish et al. (2004), who detected six species, but possibly seven if you include their possible observation of Lipinia noctua. The last species we detected was *Nactus pelagicus*, which appears widespread but in low density around the island.

We detected rats only on our first survey of the island (Table 3), consistent with eradication or reduction in response to the bait treatment. We did detect more yellow crazy ants on the first survey then the following ones (Table 4). This appeared due to the dramatic changes to the beaches (Vini and Nu'utele) following the tsunami wave of September 2009. Prior to that these ants were found on both beaches, but had not erupted yet as they have done on Nu'ulua.

We did notice a big die off of native strand trees after the tsunami and a large recruitment of young coconuts that arrived to the island. This should be monitored to make sure that the forest does not transition to a coconut stand from the diverse vegetation that was there previously.

Nu'ulua

This is the most remote island but contains excellent forest habitats. Particularly of interest is the Pisonia grandis stand behind the beach. We found six species of lizards on this island, adding one to the list of Parrish et al. (2004). The new record was for Lipinia noctua. We only ran sticky traps after the first rat baiting and never caught a rat on traps on this island. We did find Emoia adspersa much more widespread on this island then was previously known and found them on the beach forest as well as the top of the island. We detected Lipinia only on the ridgeline.

This island is overrun by yellow crazy ants, and that is almost the only thing we captured on the sticky traps. We saw a reduction in ants on the beach after the tsunami wave, as we noticed on Nu'utele, but no change on the ridgeline, except possibly greater numbers.

As with Nu'utele we saw a die-off of the native trees and good coconut recruitment after the tsunami wave. This should be monitored, as the strand vegetation there appeared very diverse.

5.0 Results for Species

Below we briefly review our findings for all species detected on the Aleipata Island surveys. We detected two species from the islands that were not previously detected by Parrish et al. (2004). One was the native gecko *Nactus pelagicus*, and the other was the invasive house gecko *Hemidactylus frenatus*. We also present initial data on habitat use by the lizards captured on the sticky traps (Table 5).

Gehyra oceanica

This species was widespread and common on all islands during our surveys. It is a large species that is an important part of the natural ecosystem on these islands.

Hemidactylus frenatus

This species is an aggressive invasive that was introduced into Samoa in the 1980s and has been spreading since then. It was detected on Namua Island and is a recent invader there. Biosecurity protocols will be necessary to ensure that this species does not invade the rest of the Aleipata Islands.

Lepidodactylus lugubris

This species was widespread but not common on all of islands. This species is parthenogenic so only females are present in the wild.

Nactus pelagicus

Species was recorded for the first time on the Aleipata Islands. It was not uncommon on Nu'utele, and also present on Namua. It probably occurred on Nu'ulua but is either absent or extremely rare due to the yellow crazy ants. It also is a parthenogenic species with only females present.

Emoia adspersa

This species is endemic to Samoa (not present in American Samoa except Swains Island), Tonga, and Tokelau. We detected this species only on Nu'ulua Island. It is probably restricted to this island due to competition or predation by *Emoia nigra* on the other three islands. We found it along the beach but also all the way up the ridge. It was not common but was widespread.

Emoia tongana

This species is endemic to Samoa (not present in American Samoa), Tonga, and Futuna. We detected this species only on Nu'utele Island. Before the rat eradication program we only detected it on Vini Beach, but after the treatment we also detected it on the ridge. This could be due to rat predation limiting its distribution before or a reduction in predation by *Emoia nigra*, which was the dominant skink on the ridge. It was suggested that *Emoia nigra* might have been impacted by the rat baits, as it is a large and aggressive species and some were noticed by the team to be dead during the treatment event. By August 2010 *Emoia nigra* numbers appeared to be similar to those prior to bait treatment (June 2009).

Emoia cyanura

This species was very common on most of the islands surveyed. It appears to be limited to beaches due to predation by *Emoia nigra*. Only on Nu'ulua, where *Emoia nigra* is absent, did we detect it up on the ridge. It is probably a very important part of the terrestrial food web on these islands.

Emoia impar

This species was only detected on two islands, both in places without *Emoia nigra*. *Impar* tends to prefer forest habitats and cyanura prefers more open and disturbed habitats (Bruna et al. 1996). On Namua it was restricted to the edges of the resort, where the native forest comes to the edge of the lawns, an area where *Emoia nigra* was rare or absent. On Nu'ulua it was the most common skink, more so even than *Emoia cyanura*. It is probably a very important part of the terrestrial food web on these islands. Its absence (or extreme rarity) on Fanuatapu and Nu'utele is probably due to its preference for the forest and the high densities of *Emoia nigra* on those islands.

Emoia nigra

This species was at the greatest densities we've seen around the Pacific on the three Aleipata Islands where it occurred. It may be driving the food web as a dominant carnivore on these islands. The distribution of *Lipinia noctua, Emoia impar,* and *Emoia adspersa* are probably limited due to this species. There is some qualitative evidence that it was negatively impacted by the rat treatment in the short term.

Emoia samoensis

This species is endemic to Samoa and American Samoa, although recent records indicate that it might also be found in northeastern Fiji. It was only found on Nu'utele Island and was most common on Vini Beach and the slopes coming up to the ridge. It appeared more common on the ridge after the rat treatment, similar to what we observed for *Emoia tongana*.

Lipinia noctua

This species is very cryptic and hard to detect. It was only captured on sticky traps on Nu'ulua and also found under rocks on the ridge. It was detected by Parrish et al. (2004) on Namua and possibly on Nu'utele, both places associated with the fales. It probably occurs still on both of these as well as Fanuatapu, but because of predation by *Emoia nigra* is very rare.

Candoia bibroni

We found only one specimen of this species on Nu'utele Island. It was detected after the rat eradication, but was found to have several scars consistent with being previously attacked by rats.

6.0 Potential threats identified

Invasive species

Three invasive species of concern for native reptiles were found in the Aleipata Islands.

The Polynesian rat (*Rattus exulans*)

The Polynesian rat, R. exulans was recorded initially on three of the four islands. After Nu'utele and Nu'ulua Islands were treated in 2009 the rats were not detected during the surveys in August of 2010. Rats continued to be detected on Namua Island into 2010. No rats were ever detected on Fanuatapu Island, and it appears that this island might have always been rat free.

Yellow crazy ants (*Anoplolepis gracilipes*)

Yellow crazy ants were recorded from three of the four Aleipata Islands. They were most abundant on Nu'ulua Island, being recorded at most sticky trap stations. They were present on Nu'utele Island although restricted to specific sites, but after the tsunami they became rare on the beaches. Possibly they are highly sensitive to the saltwater overwash and impacted by that event. They were present but rare on Namua Island and absent from Fanuatapu Island.

Pigs (*Sus scrufus*)

We continued to document pig presence on Nu'utele Island even after the rat treatment.

Improper land use management

Slash and burn agriculture continues on Namua Island, with gardens continuing to spread up towards the ridgeline, removing good forest habitat. Feral pigs and chickens on Nu'utele Island and chickens on Fanuatapu Island will have an impact on small skink populations.

7.0 Discussion, Recommendations and Conclusion

Capacity Building

Significant actions taken place includes the development and enhancement of technical skills and improved knowledge of Samoa's herpetofauna. This created close relationships between organizations involved with the implementation of this particular work program. MNRE staff has gained knowledge on the identification of lizards, geckos and snake species. More importantly it has provided golden opportunities for representatives from local communities to learn and experience on different species of Aleipata. This level of expertise is shared with other stakeholders including Quarantine Division to ensure they have similar capacity for proper identification of species at every ports of transfer within and outside the country.

Awareness Programs

The vitality of any conservation program depends primarily on how efficiently and effectively people understand about the work that is done and to be done. Local communities have had their chance to learn and communicate with the team before and after regarding certain work being conducted on the island.

Filling the Gaps

This work has provided important information on the herpetofauna of the off-shore islands of Aleipata. It currently presents a series of answers regarding the terrestrial reptiles of these islands, while on the other hand raises concerns for their conservation and status in Samoa and the region. One of the outcomes of this research (Goal 5) was the development of the "Reptiles of Samoa" brochure (Appendix attached), which was finalized and printed through SPREP. This tool is currently being utilized on the Savai'i BIORAP and by the Visitors Information Center.

Recommendation

The island group of Aleipata preserved ¾ of the herpetofauna of Samoa and thus unique components of the biodiversity of the islands. Hence it is necessary that these resources are conserved and protected following the steps identified below:

1. Biosecurity strategies be followed and understood by all. Biosecurity training was conducted in 2010 and representatives from the Aleipata and relevant stakeholders were present. There is a need for effective enforcement of biosecurity at the ports for people visiting the islands especially when moving from Upolu to a rat-free island like Nuulua or Fanuatapu, as well as control over un-noticed fishermen and visitors to the islands. The house gecko is currently found on Namu'a but there could be a possibility of live transfer of the invasive gecko on boats and people over from one island to another.
2. Ongoing monitoring in the future is necessary to keep records of the status of herpetofauna of the islands and, at the same time, strengthens MNRE capacity in developing relevant survey techniques in the field.

3. Increase awareness programs and trainings with the local communities, since they depend solely on the resources from these islands.
4. Representative Reptile Collection – This program created a voucher collection of reptile species from Samoa that is used at the Visitor Information Center located at the National Park and Reserve Office, Vailima, as material for research, training, outreach, and study.

The Aleipata Islands have herpetofaunal diversity that is representative of most of the Samoan species. Appropriate conservation actions are needed. The islands surveyed appeared to have ideal habitats for herpetofauna – but the presence of pigs (Nu'utele), yellow crazy ants (Nu'ulua), and agricultural practices (Namu'a) may have slow, long term negative impacts on these populations. Uninhabited fishing camps on the islets could lose their herpetofauna to invasive species brought in during the island visits.

8.0 Acknowledgements

Our special thanks go to Faleafaga Toni Tipamaa, Nu'utele Sagapotele, Juney Ward, Pulea Ifopo, David Butler, Alan Tye, James Atherton, Setoa Apo, Ielu Solomona, Fafetai Sagapolutele, Sayaka (JICA), Anne (Forestry), Isamaeli Asotasi, Niualuga Evaimalo, Pouono for help with the field work, transport, logistics, and support so that we could get the work on reptiles accomplished.

Funding came for staff time was provided by MNRE and USGS. Funding for travel and logistics was provided by SPREP via the CEPF Grant.

9.0 References

Bruna, E.M., Fisher, R.N., & T.J. Case. 1996. New evidence of habitat segregation between two cryptic species of Pacific skinks (*Emoia cyanura* and *E. impar*). Copeia 1996:998-1005.

Butler, D. Pages 51-55 *in* C. R. Veitch, M. N. Clout, and D. R. Towns, editors. Island invasives: eradication and management. IUCN, Gland, Switzerland.

Fisher, R. N. 2011. Considering native and exotic terrestrial reptiles in island invasive species eradication programmes in the Tropical Pacific. Pages 51-55 *in* C. R. Veitch, M. N. Clout, and D. R. Towns, editors. Island invasives: eradication and management. IUCN, Gland, Switzerland.

Gill, B. J. 1993. The land reptiles of Western Samoa. Journal of the Royal Society of New Zealand 23:79-89.

Parrish, R., I. Stringer, and P. Lester. 2004. Fauna survey of the Aleipata Islands, Samoa – 3rd Progress Report. *Institute of Applied Science Technical Report No. IAS 2004/05*. The University of the South Pacific, Fiji. 15p.

Stringer, I., R. Parrish, and G. Shirley. 2003a. Report on the first monitoring visit to Nu'utele and Nu'ulua Islands, Samoa 25-29 July 2000. *Institute of Applied Science Technical Report No. IAS 2003/10*. The University of the South Pacific, Fiji. 15p.

Stringer, I., R. Parrish, and S. Bassett. 2003b. Report on the second monitoring visit to Nu'utele and Nu'ulua Islands, Samoa 4-8 June 2001. *Institute of Applied Science Technical Report No. 2003/11*. The University of the South Pacific, Fiji. 13p.

Towns, D. R., I. A. E. Atkinson, and C. H. Daugherty. 2006. Have the harmful effects of introduced rats on islands been exaggerated? Biological Invasions 8:863-891.

Figure 1. Example of sticky trap placement in the Aleipata Islands. This figure shows Nu'ulua Island. Each flag represented a station where three traps were placed each sampling visit.

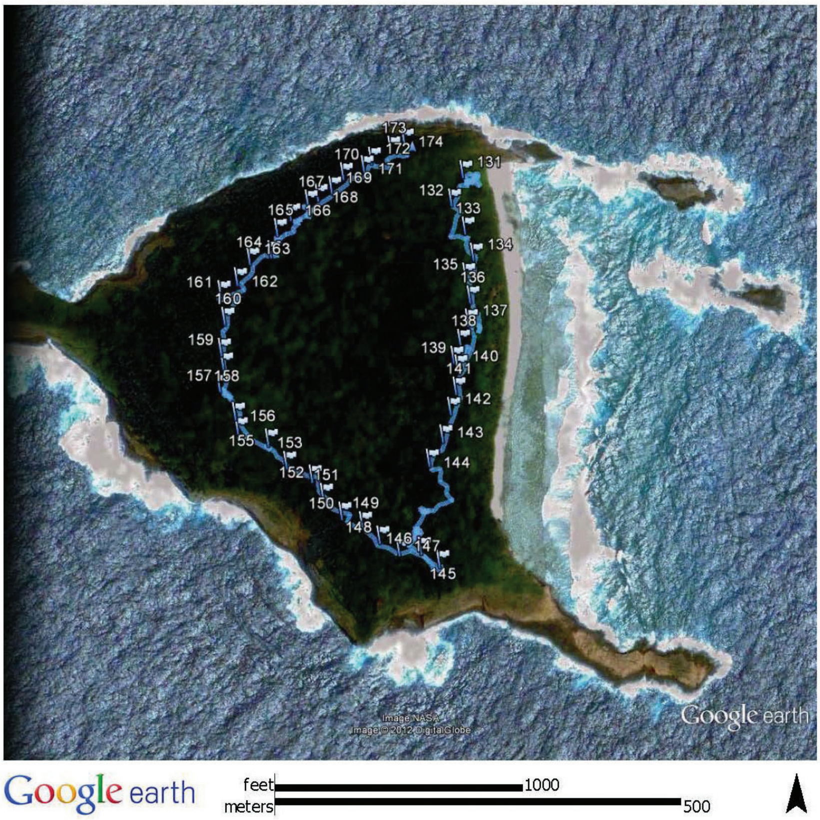


Figure 2. Photo of skinks and yellow crazy ants captured on a sticky trap. Lizards were weighed and measured and then released, and the ants were counted.

Table 1. Sampling strategy that was implemented for the Aleipata Islands for 2009 and 2010 for reptile monitoring.

Island	Site	Trap Number	Survey Type	Survey 1	Survey 2	Survey 3	Survey 4
Nu'utele Island	Nu'utele Ridge	1 - 15	Sticky Trap, Daytime, Nighttime	June, 2009	Dec., 2009	Aug, 2010	Aug, 2010
Nu'utele Island	Nu'utele Ridge	16 - 40	Sticky Trap, Daytime, Nighttime	June, 2009	Dec., 2009	Aug, 2010	Aug, 2010
Nu'utele Island	Nu'utele Ridge	41 - 60	Sticky Trap, Daytime, Nighttime	June, 2009	Dec., 2009	Aug, 2010	
Nu'utele Island	Nu'utele Beach, with YCA	1 - 25	Sticky Trap, Daytime, Nighttime	June, 2009	Dec., 2009	Aug, 2010	
Nu'utele Island	Nu'utele Beach, without YCA	26 - 50	Sticky Trap, Daytime, Nighttime	June, 2009	Dec., 2009	Aug, 2010	
Nu'utele Island	Vini Beach	1 - 15	Sticky Trap, Daytime, Nighttime	June, 2009	Dec., 2009	Aug, 2010	
Nu'ulua Island	Nu'ulua Ridge	1 - 22	Sticky Trap, Daytime, Nighttime	Aug, 2009	Dec., 2009	Aug, 2010	
Nu'ulua Island	Nu'ulua Ridge	23 - 30	Sticky Trap, Daytime, Nighttime	Aug, 2009	Dec., 2009	Aug, 2010	
Nu'ulua Island	Nu'ulua Beach	1 - 14	Sticky Trap, Daytime, Nighttime	Aug, 2009	Dec., 2009	Aug, 2010	
Namua Island	Namua Ridge	1 - 21	Sticky Trap, Daytime, Nighttime	June, 2009	Aug, 2010		
Namua Island	Namua Beach		Daytime, Nighttime	June, 2009	Aug, 2010		
Fanuatapu Island	Fanuatapu Ridge	1 - 20	Sticky Trap, Daytime, Nighttime	Dec., 2009	Aug, 2010		
Fanuatapu Island	Fanuatapu Slope	1 - 10	Sticky Trap, Daytime, Nighttime	Dec., 2009	Aug, 2010		
Fanuatapu Island	Fanuatapu Beach	1 - 10	Sticky Trap, Daytime, Nighttime	Dec., 2009	Aug, 2010		

Table 2. Reptiles detected on each island during the 2009/2010 surveys. Nactus pelagicus is a native species recorded from the islands for the first time during these surveys. Hemidactylus frenatus is an invasive recorded for the first time. Relative abundance is presented below; A = Abundant, C = Common, R = Rare.

Species	Fanuatapu	Namua	Nu'ulua	Nu'utele
Emoia nigra	A	A		A
Emoia cyanura	A	C	A	C
Emoia tongana				R
Emoia samoensis				C
Emoia adspersa			R	
Emoia impar		R	C	
Lipinia noctua		Parrish et al. 2004	R	? Parrish et al. 2004
Gehyra oceanica	C	C	C	C
Lepidodactylus lugubris	R	R	R	R
Nactus pelagicus		R		R
Hemidactylus frenatus I		R		
Candoia bibroni				R
	4	8	7	9

Table 3. Rat sticky trap capture results for Aleipata Islands during 2009 and 2010. No rats were ever captured on Fanuatapu or Nu'ulua Islands. Nu'ulua Island was trapped first during the rat eradication treatment because the seas were too rough in June of 2009 for a landing to conduct the pre-treatment assessment.

Island		Total Trap Stations	Total Traps	G	L	T	Total Captures	Capture rate
Nu'utele	June 2009	125	375	3	21	2	26	0.069
	December 2009	125	375	0	0	0	0	0
	August 2010	125	375	0	0	0	0	0
	August 2010	40	120	0	0	0	0	0
Namua	June 2009	21	63	1	0	0	1	0.016
	August 2010	21	63	1	2	0	3	0.048

Table 4. Ant sticky trap capture results for Nu'utele Island during 2009 and 2010.

Island		Total Trap Stations	Total Traps	G	L	T	Total Captures	Capture rate
Nu'utele	June 2009	125	375	11	12	7	30	0.08
	December 2009	125	375	3	3	1	7	0.02
	August 2010	125	375	2	3	2	7	0.02
	August 2010	40 (only ridge)	120	0	0	0	0	0

Table 5. Habitat use by the reptile species captured on sticky traps on the Aleipata Islands during 2009 and 2010.

	Trap Habitat Type			
Species	Ground	Log	Tree	Total
Emoia nigra	119	112	7	238
	50%	47%	3%	
Emoia cyanura	26	22	2	50
	52%	44%	4%	
Emoia tongana	0	3	6	9
	0%	33%	67%	
Emoia samoensis	11	11	5	27
	41%	41%	19%	
Emoia adspersa	2	1	0	3
	67%	33%	0%	
Emoia impar	5	6	0	11
	45%	55%	0%	
Gehyra oceanica	2	9	21	32
	6%	28%	66%	
Lepidodactylus lugubris	0	6	6	12
	0%	50%	50%	
Nactus pelagicus	1	4	1	6
	17%	67%	17%	

Herpetofauna of Samoa

Samoan Archipelago has a total number of 16 species of terrestrial reptiles. There are nine skinks, five geckos and two snake. Cane toads believed to have been accidentally introduced were recently being caught and killed but no population has been established in Samoa except Am. Samoa. Most species are native to the neighboring Islands and to Polynesia except one, the Samoan (brown) skink, is endemic to the Samoan Archipelago.

Difference between geckos and skinks.

Geckos	Skinks
Unique vocalization, chirping sound	none
Huge round eye pupils and no eye lids	Movable eyelids except the snake eyed skink
Toe pads that enable movement on smooth surfaces and are mostly nocturnal	Ear holes visible, Diurnal, and are opportunistic feeders.

Distribution
Unlike birds, skinks and geckos cannot easily travel between islands. It is expected that they either naturally dispersed by rafting or accidentally and/or intentionally were brought in by the early Polynesian seafarers. Their spatial distribution within and between Islands is accounted for mostly by humans.

Threats
Habitat destruction, forest fires, invasive species such as tree snakes, rats and natural predators can become major threats.
There is only one invasive gecko identified , the House gecko (Pili mo'o) and one invasive snake, the blind snake.

Conservation status
The main conservation action recommended is conservation of native forest and vegetation.
Pacific boa is regulated under Appendix II of CITES.

Conservation Projects and Programs
A project to eradicate rats from the Aleipata Islands, funded by the Critical Ecosystem Partnership Fund, has identified the importance of these islands for conserving the reptiles of Samoa; its monitoring results should reveal the benefits of rat eradication to an island reptile community.

To strengthen information exchange, the Two Samoans Initiative works to ensure effective conservation projects and programs within the archipelago. On the other hand the Samoa National Biodiversity Strategy and Action Plan clarifies the need for extensive research on all fauna and flora of Samoa including reptiles in order to

POTENTIAL SPECIES AND INVASIVES.
1. Rainbow skink
2. Metallic skink
3. Brown anole
4. Gold-dust day gecko
5. Cane toad (Bufo marinus)

If seen please contact us @ **Division of Environment and Conservation.**
DBS Building, Level 5.
Phone #: +(685) 23800 or email: info@mnre.gov.ws
Website: http://www.mnre.gov.ws

Reptiles of the Samoan Archipelago

MNRE

Ministry of Natural Resources and Environment
Division of Environment and Conservation

Prepared by: Moeumu Uili

USGS science for a changing world

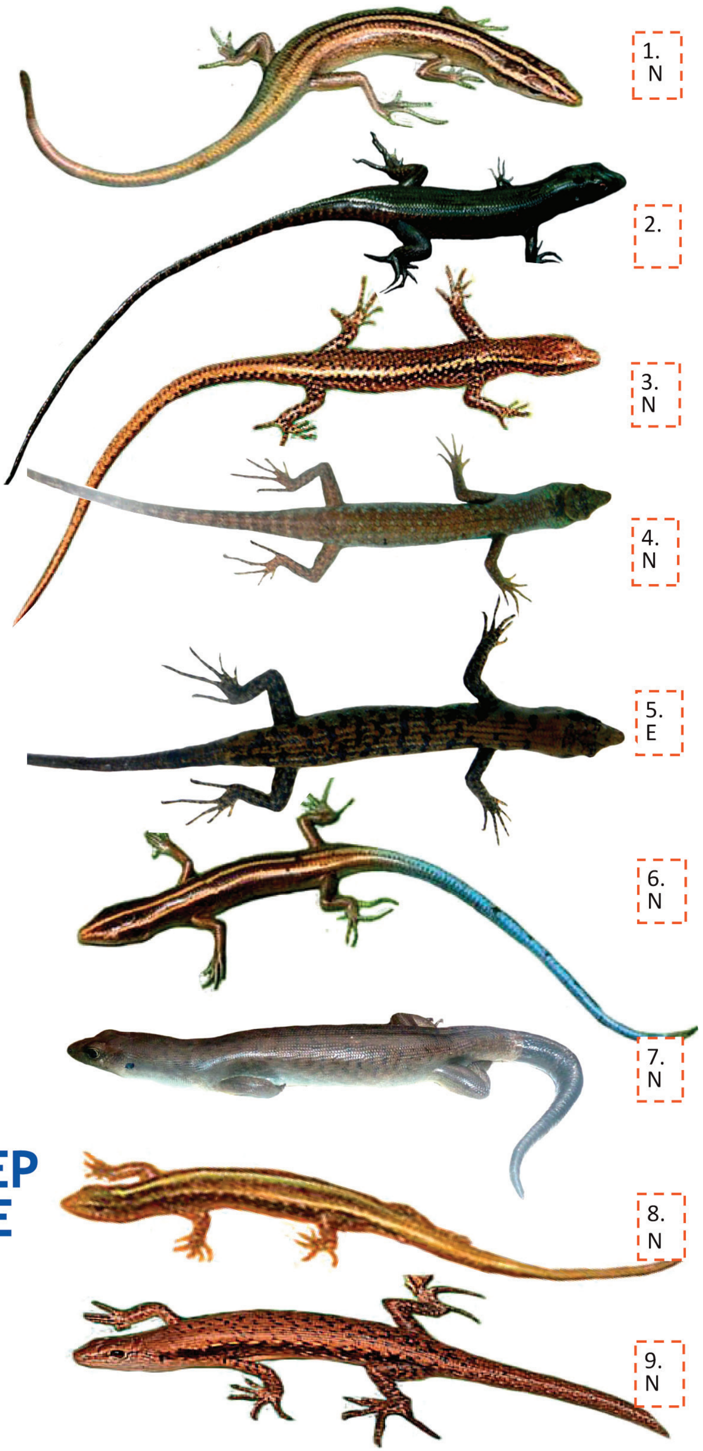
SPREP PROE

CONSERVATION INTERNATIONAL Pacific Islands

CRITICAL ECOSYSTEM PARTNERSHIP FUND

Photos in this document courtesy of Robert Fisher (USGS), NPS (Am. Sam) and MNRE.

© MNRE



10
N

11
I

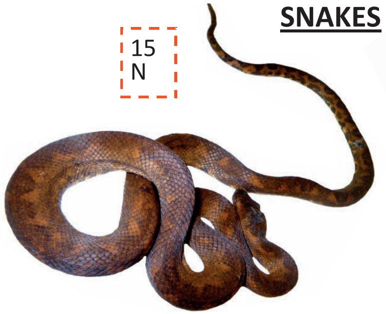
12
N

13
N

14
N

SNAKES

15
N



16
I

Plate 9—14: Gecko species

10. Oceanic gecko (AS)

Mo'o
Scientific Name: *Gehyra oceanica*

Description: Brownish yellow body sometimes color changes to dark brown depending on the environment it is exposed to. Common on the Aleipata off-shore Islands both in disturbed and undisturbed forests. They have broad toes with nails that come out in the middle of each toes. Their skin tears very easily. They are the largest native gecko.

11. Mourning gecko (AS)

Mo'o
Scientific Name: *Lepidodactylus lugubris*

Description: Light brown body with deep brown black scales and a tail that is always curled. This is a parthenogenic species with only females present. Smaller than all other geckos

12. House gecko (AS)

Pili mo'o
Scientific Name: *Hemidactylus frenatus*

Description: Soft light yellow brownish body. Widespread in Samoa except the uninhabited Islands. The only invasive gecko species common in houses where there are artificial lights. Toe nails that are similar to oceanic gecko. This geckos makes the "chuk chuk" sound at night.

13. Slender toed gecko (AS)

Mo'o
Scientific Name: *Nactus pelagicus*

Description: Brown with dark scales and has keels on its back and slender digits, enlarged tubercles in prominent longitudinal rows along body. It is parthenogenic with only females present. It is typically a ground gecko, common around rocks and coconut husks at night.

14. Stump toed gecko (AS only)

Mo'o
Scientific Name: *Gehyra mutilata*

Description: Greyish or reddish brown dotted or uniform with darker upper body, lower surface is uniform whitish.

15. Pacific boa (AS)

Gata
Scientific Name: *Candoia bibroni*

Description: Pale or reddish brown, non venomous, snake. The females grow bigger than males and they kill their preys by constriction. Size is approx. 1.5m in length

16. Brahminy blind snake (flowerpot snake): gata (AS)

Gata
Scientific Name: *Ramphotyphlops braminus*

Description: Small wormlike snake with dots for eyes. Light or dark brown in color. This species is parthenogenic with only females present. Recently introduced into Samoa, introduced into Am Samoa probably during the 1990's.

All species listed are native to the Pacific region except one indicated above is endemic to the Samoa Archipelago.

Symbolic key identification.
AS — Found in Samoa and also occurs in American Samoa
E — Endemic
N — Native
I — Introduced

Plate 1-8: Lizard species.

1. Azure tailed skink (AS)

Pili
Scientific Name: *Emoia cyanura*

Description: Brown slim body with pale yellow greenish tail and yellow stripes on upper body. Also known as white bellied skink. This species favours shaded areas and areas of secondary growth.

2. Black skink (AS)

Pili uli
Scientific Name: *Emoia nigra*

Description: Common black solid species in the forest. Often seen on ground and on logs. The largest species of skink in Samoa.

3. Snake eyed skink (AS)

Pili
Scientific Name: *Cryptoblepharus peocileoplurus*

Description: Chocolate brown body with light brown stripes and no mid dorsal white stripe. Body length about <60mm, flattened and has no eye lids. Few records in Samoa but widespread in Polynesia. Normally found along shorelines primarily rocky areas.

4. Green skink

Pili meamata
Scientific Name: *Emoia tongana*

Description: Light green body, metallic brown scales on upper body and greenish on the lower part. Common on shrub forest and secondary forest. Seen basking on trees during the day. Reported from Nuutele Island off eastern end of Upolu Island Samoa.

5. Samoan [Brown] skink (AS)

Pili lape
Scientific Name: *Emoia samoensis*

Description: Greenish body with brown upper part and black scales from head to tail. This species has similar sizes to the black skink and is also common in the forest on tree trunks.

6. Blue tail skink

Pili
Scientific Name: *Emoia impar*

Description: Also known as dusky bellied skink, has brown "bronze" body with long thin blue tail. Very common in forest areas usually on the ground or low logs.

7. Lawes olive small-scaled skink. (AS only)

Pili
Scientific Name: *Emoia lawesii*

Description: Olive brown body with small scales. Large skink. Occurs along rocky shoreline and other habitats on off-shore islands in American Samoa only

8. Moth skink (AS)

Pili
Scientific Name: *Lipinia noctua*

Description: Brown body similar to azure tail but is distinctively different by the mid yellow dorsal stripe with a yellow spot on the head. This species is more cryptic in its activity. Found under rocks and under bark. Seen basking on trees when larger *Emoia* skinks are not present.

9. Micronesian skink (AS)

Pili
Scientific Name: *Emoia adspersa*

Description: Bronze brown with unique light brown stripes sideways on the back with small scales over body. Few records found in Samoa including on Nu'ulua Island along the shorelines. Medium body length approx. 70mm. Only on Swains Island in Am Samoa.

APPENDIX 2

Report

Island biosecurity training f or Nu'utele and Nu'ulua Islands (Aleipata Island Groups), Apia, Samoa

8–11 March 2010

Pacific Invasives Initiative

Marleen Baling* and Bill Nagle, 2010

Pacific Invasives Initiative, IUCN ISSG, School of Biological Sciences,
The University of Auckland, Private Bag 92019, Auckland, New
Zealand. *m.baling@auckland.ac.nz

Summary

The island biosecurity training for Nu'utele and Nu'ulua Islands was held at Apia, Samoa, in March 2010. The purpose of the training was 1) to develop general understanding of invasive species and biosecurity on Nu'utele and Nu'ulua islands by the participants; 2) to develop knowledge and skills necessary to undertake basic surveillance and incursion responses; 3) to collect local knowledge for contribution to the island biosecurity plan, and 4) to develop an initial visitors' biosecurity checklist to the islands. This 4-day training course was attended by up to 22 participants from Samoa's Ministry for Natural Resources and Environment (MNRE), the Aleipata Marine Protected Area (MPA) committee members, and the Samoan Ports Authority (SPA). The training covered the three steps of biosecurity (quarantine/prevention, surveillance, incursion response), and introduced basic concepts and theory to the participants. These topics were reinforced with several practical exercises, which included a fieldtrip to Satitoa wharf to examine biosecurity issues at the departure site. The participatory approach of this training was to encourage personal opinions and experiences to be shared and discussed by the group. All participants expressed an increased level of understanding on invasive species, its current issues, and importance of biosecurity to the islands. The participants agreed with the need for public awareness on the importance of biosecurity for the islands. Several recommendations for future actions have been identified, and will be discussed in the following months.

Nu'utele and Nu'ulua Islands (Aleipata Island Group) are identified as key sites for ecological conservation in Samoa. A long-term restoration project included the eradication of rats in 2009, under Samoa's National Biodiversity Strategy and Action Plan, and the Aleipata Marine Protected Area (MPA) Management Plan (2002-2006). This project has joint collaboration between the local communities from the Aleipata District (MPA members), Samoa's Ministry for Natural Resources and Environment (MNRE), Secretariat of the Pacific Regional Environment Programme (SPREP), New Zealand Department of Conservation (DOC), Conservation International – Pacific Islands Programme (CI-PIP), the Critical Ecosystem Partnership Fund (CEPF), and Pacific Invasives Initiative (PII).

All stakeholders identified the need for biosecurity awareness and skills, and PII was requested to develop and deliver an island biosecurity training course for key community members and MNRE staff. The first training was held in September/October 2009 at Auckland, New Zealand and was attended by five Samoan participants. However the training was prematurely stopped due to the tsunami that struck Samoa on the 30 September 2009. MNRE, community members and SPREP requested the training be completed in Apia, Samoa.

This report presents an overview of the result of the island biosecurity training repeated in Apia, Samoa, between 8 and 11 March 2010.

Purposes

To develop understanding of biosecurity, its purpose and the practicality of maintaining effective biosecurity programmes, to minimise the risk of invasive species re-invading Nu'utele and Nu'ulua islands.

To develop knowledge and skills necessary to undertake basic surveillance and incursion responses.

To collect information from local knowledge that will contribute to the biosecurity plan for the islands. This will be finalised jointly with MNRE and SPREP.

To develop an initial checklist for visitors to the islands. This will be finalised jointly with MNRE and SPREP.

Training days

The training course started on the 8th March 2010, with opening speeches and Samoan biosecurity presentations from MNRE, and Ministry of Agriculture and Fisheries (MAF) Quarantine and MPA representative. Participants comprised of 10 Aleipata District community leaders, 8 MNRE staff, and one representative from the Samoan Ports Authority (SPA). Due to increased interest in the training, three new community members attended at the later stage of the training. Additionally two representatives from CI-PIP/ CEPF attended the morning of the third day of the training. Translation between English and Samoan was made by MNRE staff.

The training course was lead by Marleen Baling and Bill Nagle. Similar to the previous biosecurity training, a participatory approach was used to establish an understanding of basic biosecurity concepts and gain local information on both Nu'utele and Nu'ulua Islands. The training covered the three basic steps of biosecurity: quarantine/ prevention, surveillance and incursion response. These steps carried the important messages of: not bringing any unwanted biota to the islands, being vigilant in looking for anything unusual (invasive species) on the island, and to report any unusual sightings immediately. Opinions and personal concerns from each participant were encouraged and discussed, and issues resolved where possible.

The concept of the training was reinforced by several exercises, which looked at basic monitoring methods (ant lures and tracking tunnels), quarantine procedures (participants checked equipment for unwanted biota), poster on comparison between "good" and "bad" island biosecurity, and a visit to Satitoa wharf to discuss biosecurity at the boat launch site. Discussions on practicality and other concerns were made at the end of each exercise.

Outcomes

1. UNDERSTANDING BIOSECURITY

1. Participants admitted a previous lack of understanding of invasive species, their impact and the function of biosecurity. This training has increased their knowledge and desire to put action to invasive species prevention not only for the Aleipata Islands, but also the main island (Upolu).
2. Participants repeatedly expressed concern about unauthorised landings (e.g. fishermen and foreign visitors) on Nu'utele and how that will increase the biosecurity risk for the island. All participants agreed on the need for public awareness and participation.
3. Participants understood and agreed to the need for rapid reporting in the event of an invasive species incursion on the islands.
4. The SPA representative expressed interest in island biosecurity and encouraged more contact between MNRE, MPA and SPA, in order to update all agencies about the Aleipata Island issues.
5. There were recommendations from the participants to hold such biosecurity training periodically in Samoa, to teach and create awareness in others.

2. DEVELOPMENT OF SKILLS AND KNOWLEDGE

1. Participants were made aware of risk areas (places to look for signs of incursions) on the island and the means of identifying signs of invasive species incursions.
2. The lure and rat tracking exercise provided skills in setting and collecting samples, and interpreting the information.

3. LOCAL KNOWLEDGE AND INFORMATION COLLATION

1. Information about the islands (risk areas, common landing route), risk species, its source and invasion pathway were collected from participants and will be drafted into the islands' biosecurity plan.

4. DEVELOPMENT OF VISITOR CHECKLIST

1. Information of the type of visitors and equipment usually taken to the island were compiled and a draft of a visitor checklist has been made.

ADDITIONAL

The need for a protocol for incursion response for the Aleipata Islands was identified, and to be resolved. For example, who is responsible in each step of the response plan – MNRE, MAF Quarantine, Samoa National Invasive Technical Team (SNITT), or MPA? Is the national emergency response plan for invasive species applicable to local issues (i.e. rat incursion on Nu'utele and Nu'ulua)? Who is responsible for writing up the response plan – MNRE, MPA or SNITT? How does this all fit into the MPA management plan?

NEXT COURSE OF ACTION

The following list of actions were raised, discussed and recommended from the biosecurity training. A simplified table is drafted and attached at the end of this report, and a dateline needs to be set by each party.

1. PII to draft the biosecurity species risk invasion pathway and prevention measures for Nu'utele and Nu'ulua Islands. This will be sent to MNRE and SPREP to finalise plan.
2. PII to draft the visitor checklist for Nu'utele and Nu'ulua Islands. This will be sent to MNRE, MPA and SPREP to finalise document.
3. Establishment of an incursion response plan for Nu'utele and Nu'ulua Islands. This includes clarification of the roles and responsibilities of each agency (MNRE, MPA, SNITT or MAF Quarantine?) in an event of an incursion. Management measures for high risk species (e.g. rats) need to be produced. Suggestion for MNRE, MPA and SPREP to discuss this part of the biosecurity plan, with support from PII.
4. MNRE and MPA will start basic quarantine checks of all gear prior to departing to the islands (using the visitor checklist). This will be routine in future island visits. MNRE and MPA to discuss their roles as 'quarantine officers'. Who will be responsible?
5. MNRE and MPA to discuss the establishment of an MPA/quarantine office at Satitoa.
6. Further discussion between MNRE, MPA, SPREP and PII on community awareness for the Aleipata Islands.
   Questions raised in the training:
   Who are the community targets (fishermen, tourists, school children)?
   How are we promoting biosecurity on Aleipata Islands (poster, presentation, community day)?
   Who will be promoting this (MNRE, MPA)?
   How long or how often will this programme be held?
7. MNRE to send the translated biosecurity training evaluation forms (Samoan to English) to PII.

Acknowledgements

We would like to thank everyone who has contributed to this training course, including MNRE (especially Malama Momoemausu, Pulea Ifopo, Moeumu Uili, Lesaisaea Evaimalo and Faleafaga Toni Tipamma), SPREP (Alan Tye), MPA, SPA, and CI-PIP (James Atherton and Leilani Duffy), Dave Butler, Alejandra Torres, PII team, Sonia Frimmel, Carola Warner and Rob Chappell. Funding for this training and project was received from CEPF and NZAID.

List of people in the island biosecurity training, Apia, Samoa 8–11 March 2010.

Full training

No.	Names	Affiliation
1	Nuutele Sagapolutele	Ulutogia
2	Seuala Patone	Lalomanu
3	Amiaitutolu Ionatana	Vailoa
4	Maria Oloisepu	Malaela & Mutiatele
5	Tiumalu Amakisi	Saleaumumu
6	Tavana Iefata	Lotopue
7	Taua Vae	Samusu
8	Tafaoatua Pepa	Utufaalalafa
9	Tolu Iakopo	Tiavew
10	Ierome Mulumulu	Samoa Ports Authority (Aleipata Wharf)
11	Pulea Ifopo	MNRE/ MPA
12	Moeumu Uili	MNRE
13	Elizabeth Kerstin	MNRE
14	Malama Momoemausu	MNRE
15	Titi Simi	MNRE

Part-training

No.	Names	Affiliation
1	Tuiluaai Loakimo	Amaile
2	Faleafaga Toni Tipamaa	MNRE
3	Lesaisaea Evaimalo	MNRE
4	Juney Ward	MNRE
5	Letoa Tula	Ulutogia
6	Seufale Lauvao	Saleaumua
7	Fueloa Tavita	Utufaalalafa

Guests/ observers

No.	Names	Affiliation
1	Iaumuna Akerei Leau	MAF Quarantine
2	James Atherton	CI-PIP/ CEPF
3	Leilani Duffy	CI-PIP/ CEPF

Facilitators

No.	Names	Affiliation
1	Marleen Baling	PII
2	Bill Nagle	PII

Planned actions to be taken by various agencies, following the island biosecurity training (8–11 March 2010), Samoa

No.	Action process	Responsible	Due date	Status
1.	Biosecurity management measures a) Draft biosecurity management measures identified from training – risk species, invasion pathway, preventative measures. b) Add – incursion response measures. c) Review and refine.	PII MNRE/ MPA MNRE/MPA/ SPREP/PII	02 April 2010 30 April 2010 31 May 2010	Ongoing
2.	Visitor biosecurity checklist a) Draft visitor checklist. b) Add-introduction. c) Review.	PII MNRE/MPA MNRE/MPA/ SPREP/PII	02 April 2010 19 April 2010 30 April 2010	Ongoing
3.	Quarantine a) Discuss potential establishment of quarantine/ MPA office at Satitoa. b) Decide on who is responsible as 'quarantine officers' for the islands.	MNRE/MPA MNRE/MPA		
4.	Community awareness a) Hold a community day for Aleipata District. b) Collate ideas from MNRE/MPA/CI-PIP, for raising awareness in the wider community – draft c) Review ideas, options, and logistics. d) Finalise a community awareness programme d) Implementation.	MNRE/MPA PII MNRE/ MPA/SPREP/ PII MNRE/MPA MNRE/MPA	30 April 2010	
5.	Send biosecurity training evaluation forms to PII.	MNRE	9 April 2010	

Nu’utele and Nu’ulua Islands on the horizon, seen from the south coast of Upolu Island, Samoa.

APPENDIX 3

Final Report

The status and impacts of Yellow Crazy ant (*Anoplolepis gracilipes*) on Nu'utele, Aleipata islands, Samoa

8–11 March 2010

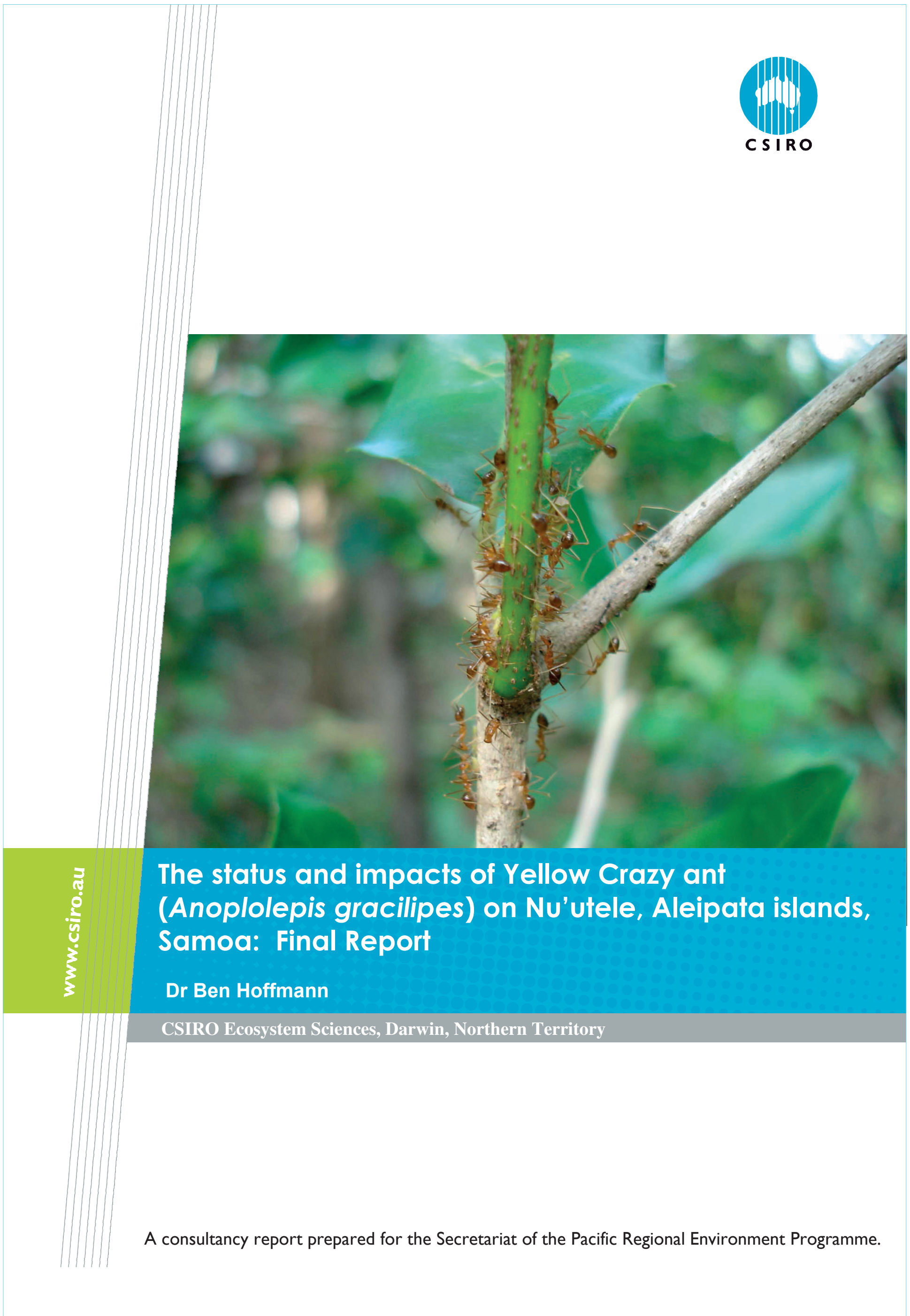
CSIRO

Dr Ben Hoffmann

CSIRO

CSIRO Ecosystem Sciences, Darwin, Northern Territory

A consultancy report prepared for the Secretariat of the Pacific Regional Environment Programme.



CSIRO

www.csiro.au

The status and impacts of Yellow Crazy ant (*Anoplolepis gracilipes*) on Nu'utele, Aleipata islands, Samoa: Final Report

Dr Ben Hoffmann

CSIRO Ecosystem Sciences, Darwin, Northern Territory

A consultancy report prepared for the Secretariat of the Pacific Regional Environment Programme.

DISCLAIMER

Although every effort has been made to ensure the accuracy of the information in this document, CSIRO nor the authors shall not be liable for the results of any actions arising out of the use of any information, suggestions or recommendations contained in this publication. To the extent permitted by law, CSIRO Ecosystem Sciences (including its employees and consultants) excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

Executive summary

This report describes research conducted in October 2010 and May 2011 on the island of Nu'utele, Samoa with the following aims:

- To determine yellow crazy ant, *A. gracilipes* distribution and quantify rate of spread from the historic distribution;
- To quantify the reproductive phenology of *A. gracilipes*;
- To quantify the annual abundance cycle of *A. gracilipes*;
- To quantify the annual nest density cycle of *A. gracilipes*;
- To quantify *A. gracilipes* impacts on co-existing fauna
- To identify *A. gracilipes* interactions with phytophagous insects and extrafloral nectar
- To provide management recommendations

Where possible, results from Nu'utele are compared with identical measurements from Christmas Island, Indian Ocean and throughout Arnhem Land, Australia, where *A. gracilipes* is well studied and is also subject to management actions.

Distribution and rate of spread

Yellow crazy ant was found occurring in three populations: Nu'utele beach (0.37 ha); Vini beach (> 2.6 ha); and the western ridge top (1.36 ha), and also as two isolated detections on the central ridge. This distribution contrasts greatly to the results of the 2003 survey, where only a single population was found covering approximately 8 ha on Nu'utele beach. The reason for the great reduction in population size at Nu'utele beach is unclear. The maximum rate of spread was 20 m over seven months. This distance is consistent with the expected expansion rate of a population approximately six years old.

Reproductive phenology

Male reproduction patterns in Samoa appear to be consistent with places elsewhere globally, but this is not so for queen reproduction because only a single queen pupa was collected from a nest excavated in May, which is outside of the known reproductive period for this species.

Annual abundance cycle

Worker counts on cards and tuna lures confirmed the expectation that worker abundance would be greatest in the May sample. Abundance from card counts was on average 30 ants in October, compared to 83 in May. The average abundance score from tuna lures was 4 (ranging from 11-20 ants) in October and over 7 (> 100 ants) in May. The *A. gracilipes* population levels on Nu'utele during their times of high abundance are as great as those seen on Christmas Island, but fall below this critical level during the time of low abundance. From pupal samples it is clear that the abundance levels from Samoa are much greater than those from Arnhem Land, during comparable time periods, and it appears likely that there is also a difference in the period of greatest ant abundance, with pupal abundance increasing earlier in Samoa than in Arnhem Land.

Annual nest density cycle

Seasonal variation in nest densities conformed to expectations, being greater in May (one nest per 2.2 m2) when population levels were also greater, than in October (one per 4.4 m2). The nest density on Nu'utele is among the highest recorded anywhere in the world.

Impacts

A total of 24 ant species from 15 genera were collected within pitfall traps. The most abundant species (excluding *A. gracilipes*) were *Pheidole umbonata* (46.2% of total abundance), the exotic tramp *Paratrechina longicornis* (18.6%), and *Odontomachus simillimus* (17.4%). *Anoplolepis gracilipes* abundance within the infested plots was always much greater than the abundance of all other ants combined in either plot, being 7.6 and 5.9 times greater than native ant abundance within the infested and uninfested plots respectively in the 2010 sample, and 2.7 and 3.5 times greater respectively in 2011.

Other ant abundance was not statistically different between infested and uninfested plots in both sample times. However, other ant abundance was dominated by a single species, *Pheidole umbonata* (51% and 44% in the 2010 and 2011 samples respectively), and with this species excluded, other ant abundance was significantly lower within the infested plots (average 5 ants per plot) compared to the uninfested plots (11 ants) within the 2010 sample, but not in the 2011 sample. Ant species richness per plot was consistently greater within the infested site, and this difference was statistically significant in the 2011 sample, having an average of six species per plot in the infested site vs three in the uninfested site. The greater species richness in the infested plot in the 2011 sample was predominantly due to other native ant species rather than other exotic species (8 species vs 4 respectively).

Nine ant species from seven genera were collected within foliage beats. Excluding *A. gracilipes*, four exotic tramps comprised 86% of total abundance within both samples combined, being *Tapinoma melanocephalum* (39%), *Paratrechina longicornis* (23%), *Monomorium floricola* (19%) and *Tetramorium bicarinatum* (5%). Within the infested site the abundance of other ants was 2.6 and 1.8 times greater than that of *A. gracilipes* in the 2010 and 2011 samples respectively, but these differences were not statistically significant. Similarly, other ant abundance within the uninfested site was not statistically different from *A. gracilipes* abundance in the infested site in the 2010 sample, but was statistically greater in the 2011 sample. There was no significant difference between the abundance and species richness of other ants between the infested and uninfested sites in both sample times.

Other macro-invertebrates from 11 orders were collected in pitfall traps. Flies were the predominate group collected (46% of all samples combined). There was no difference in the overall abundance or ordinal richness of other macro-invertebrates between the infested and uninfested sites within any of the two sample times. There was a clear trend of fewer spiders within the infested site (5 vs 18 individuals in 2010 and 2 vs 16 in 2011), but this was not statistically significant.

Other macro-invertebrates from eight orders were collected in foliage beats. Spiders were the predominate group collected (37% of all samples combined). Just as for other macro-invertebrate data from pitfall traps, there was no difference in overall abundance or ordinal richness between the infested and uninfested sites within either of the two sample times. Spiders had fewer individuals within the infested site in both sample times, statistically significantly so in the 2011 sample.

There was a clear difference in total hermit crab abundance between infested and uninfested sites in both sample times. In the 2010 sample, when *A. gracilipes* abundance was lowest, the infested site had approximately one quarter of the crabs per plot of the uninfested site, being greatly statistically different. This statistical result was driven by large crabs. Only seven small crabs were found in the infested site compared to 28 in the uninfested site, but the proportion of small crabs to the total count was consistent between the two sites (27% and 26% respectively), indicating that any factor affecting hermit crab abundance applied equally to both size classes. The difference in crab abundance between the infested and uninfested sites were even more pronounced in the 2011 sample when *A. gracilipes* abundance was greater, with only four large crabs being found in the infested site, compared to an average of 2.7 crabs per sample in the uninfested site. Naturally this difference was highly statistically significant.

Interactions with phytophagous insects and extrafloral nectar

Multiple unidentified species of scale and at least one mealy bug species were found on six tree species. The only interaction noticed between *A. gracilipes* and these insects was with scales on Indian Mulberry (Nonu) *Morinda citrifolia*, but all of the insect species were found within the infested site. Six plant species were found to have extra floral nectaries or carbohydrate sources accessible to ants, but *A. gracilipes* was found attending these sources only on the Indian Mulberry. The infested site had approximately double the number of trees with EFNs (41%) compared to the uninfested site (26%). Similarly, phytophagous insects were found on 29% of assessable trees within the infested site compared to only 4% within the uninfested site. It is not possible to state whether the current distribution of *A. gracilipes* on Vini beach is a consequence of the vegetation composition (and hence EFN availability), or merely by chance, or to what extent vegetation composition on Nu'utele could potentially limit the distribution of *A. gracilipes*. Similarly, it is unclear whether the greater phytophagous insect density within the infested site is a cause or consequence of the *A. gracilipes* distribution.

Management recommendations

I do not recommend eradication from the island as a management goal. However suppression of the Vini beach population and local eradication of the Nu'utele beach and western ridge populations is feasible. Regardless of management action or not, the distribution of the ant should be monitored annually to bi-annually. Research should also be continued to fill the knowledge gaps of the biology of the ant, especially the reproductive timing of queens.

Research recommendations

Monthly sampling of crazy ant nest contents and nest density should be continued to fill the knowledge gaps of the biology of the ant, especially to determine the timing of queens reproduction. Such information is critical for effective management, and should be known prior to any broad-scale management operation, because treatments should be timed around the queen reproductive phase. The distribution of the ant should be monitored annually to bi-annually to either ensure that management actions are achieving their goals or to re-assess its status and risk on the island. Additional research should be instigated to address the apparent relationship found between *A. gracilipes* distribution and the supply of carbohydrate resources from both plants and phytophagous insects. Such a deterministic relationship has never been demonstrated before between invasive ants and vegetation composition, and would allow the distribution and impacts of *A. gracilipes* within any area to be predicted based on vegetation composition. This research would require comparative work to be conducted on Nu'ulua, where *A. gracilipes* seems to be well-established island-wide.

1. Introduction

Many ant species that have been accidentally spread throughout the world have significant economic, environmental and social impacts in areas that they now infest. One of the most notable invasive ants is the Yellow crazy ant, *A. gracilipes*, and this species is present in Samoa, including on the Aleipata islands. The Aleipata islands are considered to be of great regional conservation significance because they are uninhabited, relatively pristine, contain many species threatened throughout greater Samoa, and lack many exotic species present within greater Samoa. The presence of *A. gracilipes* on these islands is therefore of great conservation concern.

Prior work among the Aleipata islands has shown that *A. gracilipes* is well distributed over the island of Nuulua (Vanderwoude et al. 2006), but is restricted to one side of the island of Nu'utele (Abbott 2006). The incomplete distribution of this ant over Nu'utele provides the greatest opportunity to investigate its spread and impact. Such information is an important component of any risk analysis underlying management options for invasive species. Similarly, *in situ* knowledge of the biology and ecology of a species, is vital to create effective management protocols. This is particularly important for *A. gracilipes* because globally there is great variation in its abundance, impacts and seasonal phenology, and its reproductive strategy is particularly problematic and unresolved (Drescher et al. 2007; Gruber et al. in press).

This report describes research investigating the distribution, biology and impacts of *A. gracilipes* on Nu'utele, conducted in October 2010 and May 2011.

The aims of the project were:

- To determine *A. gracilipes* distribution and quantify rate of spread
- To quantify the reproductive phenology of *A. gracilipes*;
- To quantify the annual abundance cycle of *A. gracilipes*;
- To quantify the annual nest density cycle of *A. gracilipes*;
- To quantify *A. gracilipes* impacts on indigenous fauna
- To identify *A. gracilipes* interactions with phytophagous insects and extrafloral nectar
- To provide management recommendations

Plate 1. Worker and queen Yellow crazy ant, Anoplolepis gracilipes. Photo courtesy of Phil Lester, Victoria University of Wellington.

2. Methods

2.1 FIELDWORK TIMING AND DATA COMPARISONS

Two field trips were conducted to obtain repeated measures, the first in October 2010 and the second in May 2011. These dates were chosen because research on *A. gracilipes* biology elsewhere has shown that these months are approximately the times of the extremes of the variation within the *A. gracilipes* reproductive and abundance cycles. It was anticipated that such trends are consistent within Samoan populations of

A. gracilipes, with reproduction of sexuals and lowest worker abundance occurring within October, and no reproduction of sexuals coupled with greater worker abundance occurring in May. Whenever possible, results were compared with identical assessments from Arnhem Land and Christmas Island, where *A. gracilipes* is subject to control or eradication measures.

The taxonomy and biogeographic origin of some Samoan ants remains problematic. Ant species were classified as either "native" or "exotic" based on the most recent revision of Samoan ants (Wetterer & Vargo 2003) and my personal opinion. Species considered to be Indo-Pacific natives were considered to be native to Samoa, as were other species (e.g. *Hypoponera punctatissima*) which are likely to be different species requiring taxonomic revision, and which are also not known to have adverse environmental impacts where they occur.

2.2 DISTRIBUTION AND RATE OF SPREAD

The presence/absence of *A. gracilipes* was assessed at all locations accessed on the island, being the gently sloped lowland areas (<20 m elevation) around Nu'utele beach (south east) and the fales on Vini beach (north and northwest), as well as the walking trail linking the north and south of the island, the far western portion of the walking trail along the ridge and some accessible steeper terrain between *A. gracilipes* detections. An assessment comprised an approximately four second visual survey of surrounds following agitation of the ground. All assessments were recorded in GPS.

Assessments of population boundaries were able to be conducted for only three of the five *A. gracilipes* populations found, and those surveys were restricted to accessible areas (approximately <300 slope and within penetrable vegetation). Delimiting surveys comprised assessments spaced <10 m apart, haphazardly made along survey paths spaced approximately 10 m apart. Wherever possible, surveys were conducted up to 100 m away in all directions from the peripheral *A. gracilipes* detections (the perceived boundary).

The area covered by the *A. gracilipes* population at Nu'utele beach was found to be greatly reduced from when it had last been assessed (Abbott 2006; Vanderwoude et al. 2008), so it could not be used to determine rate of spread. Instead the 2010 and 2011 determinations of the Vini beach population's western boundary were compared. Only this location is used for assessment because it is the only relevant boundary that was intensively and appropriately surveyed at both time periods.

2.3 REPRODUCTIVE PHENOLOGY

The reproductive strategy of this species is particularly problematic and unresolved (Drescher et al. 2007; Gruber et al. in press), and there is also enough variation in reproductive timing in different locations to necessitate the local determination of its phenology. The reproductive phenology of *A. gracilipes* was assessed by quantifying the annual patterns of male and queen pupae production. During both the October 2010 and May 2011 field trips, all pupae found within ten nests were collected, then determined in the laboratory as being either a worker, male or queen. For the October sample, five nests each were sampled from Nu'utele beach and Vini beach, but all 10 nests in the May sample were from Vini beach. Additional monthly collections were to be conducted by MNRE staff, but unfortunately this did not occur.

2.4 ANNUAL ABUNDANCE CYCLE

The *A. gracilipes* annual abundance cycle was measured indirectly from pupae counts (Section 2.2), and directly from worker counts on cards and at fish lures at the Vini beach infestation. Card and lure counts were conducted at the same sample points along transects, with the card assessments being conducted prior to fish lure assessments. Eleven sample points were spaced 5m apart along four 50m transects.

Cards were 20 cm x 20 cm laminated paper divided into four 10 cm x 10 cm squares. At each assessment point a card was placed on the ground with the edges in contact with substrate as far as possible to allow easy access for the ants to walk on card. For 20 seconds the card was observed, and the first square accessed by an *A. gracilipes* worker was the only square used for the assessment. The number of *A. gracilipes* workers walking over that square were counted over the following 30 seconds. If no ant walked over the grid in the first 20 second assessment period, then the square to be used was determined by the first ant that walked over the grid in the 30 second quantifying period. The abundance counts were pooled for each transect, then averaged among transects.

Fish lures were a teaspoon amount of canned fish. *A. gracilipes* abundance at each lure was scored after 20 minutes according to the following scale: 0 = no ants; 1 = 1 ant; 2 = 2-5 ants; 3 = 6-10 ants; 4 = 11-20 ants; 5 = 21 – 50 ants; 6 = 50 -100 ants; and 7 = >100 ants. The scaled abundance measures were averaged for each transect, then averaged among transects. Additional monthly collections of both card and lure counts were to be conducted by MNRE staff, but unfortunately this did not occur.

2.5 ANNUAL NEST DENSITY CYCLE

Nest density was quantified in four 5 x 5m plots within the Vini beach infestation, with plot location differing in the two sample times. Within each plot, nests were located by disturbing all leaf litter and surface materials. Nests were defined as locations from where ants were recruiting (i.e. a hole in the ground), or where pupae were aggregated. Nests < 50cm apart were considered to be the same nest. Additional monthly collections were to be conducted by MNRE staff, but unfortunately this did not occur. Nest density data on Nu'utele were compared with data from identical assessments from Arnhem Land and Christmas Island.

2.6 IMPACTS

All impact studies were conducted within the Vini beach infestation (Figure 1) and the nearby uninfested area to the southwest of the fales. These areas were paired as far as practicable by: (1) elevation, being near the base of the steep incline; (2) vegetation structure having an interlocking canopy and a dense understorey; and (3) the vegetation of all strata being comprised of numerous species (i.e. not a near monoculture of Coconut *Cocos nucifera* or *Pisonia grandis*). The vegetation structure and composition of these sites appears (by eye) comparable to all vegetation covering the island, other than the peripheral vegetation near the shoreline.

There are two important considerations for the impact studies. First, the absence of pre-invasion data means that impacts can only be inferred from analyses of data from areas invaded vs areas uninvaded, and differences between these areas are not necessarily caused by the invader. Second, univariate analyses in studies of invasions such as this suffer from inherent pseudoreplication because the invasion is not replicated (Hurlbert 1984). However, within comparative mensurative experiments such as this the issue of pseudoreplication is minimized when samples are conducted throughout the entire area, not just within one part of an infestation (Hurlbert 1984). Accordingly, for the main component of the impact analysis (pitfall trap data of epigeic fauna) I have used 20 small plots comprised of only three pitfall traps in both the infested and uninfested sites, instead of the more typical ant community sampling regime utilising a few large plots typically comprised of 12 or 15 traps. To further reduce pseudoreplication issues, I lowered the probability level of statistical significance to P = 0.025.

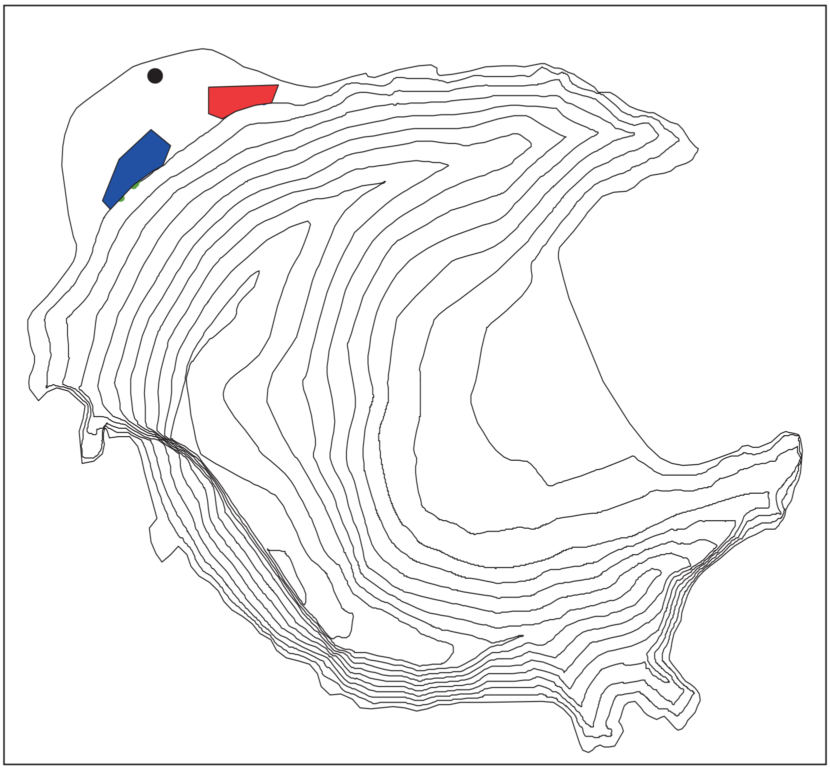


Figure 1. Location of sites at Vini beach infested with *A. gracilipes* (red polygon) and uninfested (blue polygon) used to measure *A. gracilipes* environmental impacts. The point indicates the location of the fales.

The epigeic invertebrate fauna was sampled using pitfall traps, which were plastic containers with an internal diameter of 65 mm, one third filled with ethylene glycol as a preservative. The three traps per plot were placed in triangle formation, spaced approximately 2 m apart. Plots were spaced no less than 10 m apart. All macroinvertebrates (taxa > 1 mm) were identified to ordinal level, except ants, which were identified to species level. Pitfall trap data were pooled for each plot. Foliage beats were conducted to sample the arboreal invertebrate fauna. Samples were collected along a single transect within each of the infested and uninfested sites. Where possible, assessments were made every 4 m along the transect using the closest tree (>2 m high), or low lying branch of an established tree. The transect was extended as far as needed to collect 12 samples in each site. The selected foliage was beaten four times over a 1 x 1 m white canvas, and all invertebrates that fell onto the canvas were collected.

The potential impact of *A. gracilipes* on hermit crabs was assessed by counting the number of crabs found within one minute in 20 5 x 1 m transects during the early evening between 7 and 9 pm. Crabs were divided into two arbitrary size classes: small (<5 mm across the carapace) and large (>5 mm across the carapace).

The non-parametric Mann-Whitney U-Test was used when comparing data from infested and uninfested plots, and the Wilcoxon matched pairs T-test was used when analysing data from infested samples only.

2.7 PHYTOPHAGOUS INSECTS AND EXTRAFLORAL NECTAR

All phytophagous insects, as well as plants observed with extra floral nectaries (EFNs) or with nectar sources were collected and identified. Any associations of these with *A. gracilipes* were noted. Additionally a brief survey was conducted attempting to quantify vegetation composition between the infested and uninfested sites on Vini beach. In both locations vegetation was sampled every two metres along the same transects used for foliage beat measures of *A. gracilipes* impacts (Section 2.5). At each sample location the closest tree (> 2m high) was identified, and observations were made of the presence/absence of phytophagous insects and EFNs, as well as any interaction with *A. gracilipes*.

3. Results and Discussion

3.1 DISTRIBUTION AND RATE OF SPREAD

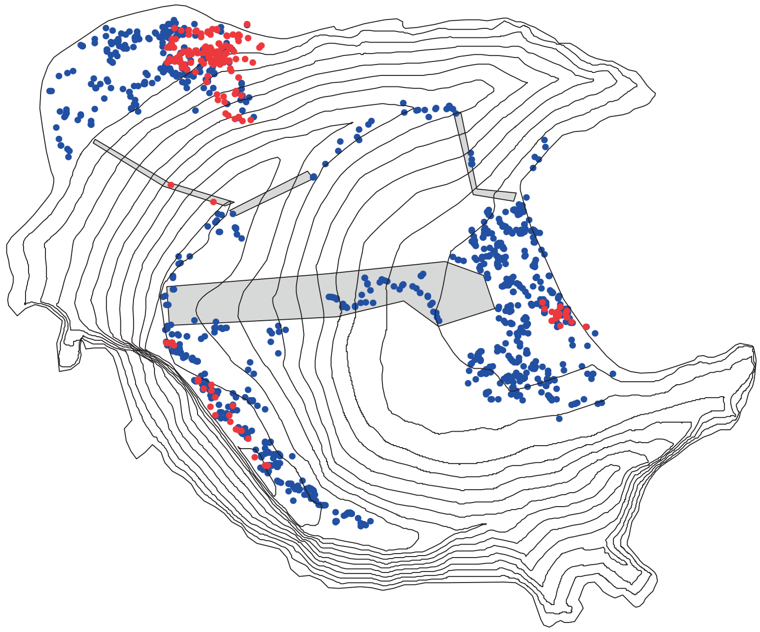
A total of 1546 point assessments were conducted, with *A. gracilipes* detected in 190 (Figure 2). The *A. gracilipes* detections were primarily within three populations. The largest was at Vini beach covering 2.64 ha of accessible terrain which could be assessed, and continuing for an unknown distance into terrain that could not be assessed. The next largest infestation was on the western ridge top, covering 1.36 ha, and the third at Nu'utele beach covered 0.37 ha. An additional two isolated detections were made along the trail on the northern slope of the central ridge. It remains unclear if these detections are part of the Vini beach population or not. Interestingly, these two detections were made in the October 2010 sampling period, but were not detected again in the April 2011 sampling period despite multiple attempts to find them.

The *A. gracilipes* distribution found here contrasts greatly to the findings of the survey conducted in 2003 (Abbott 2006). In 2003, only a single population was found on Nu'utele beach, compared to at least three populations found in 2010/2011. Also, the population on Nu'utele beach covered approximately 8 ha in 2003 but now covers

< 0.4 ha. The reason for the decline of this population remains unclear. It is possible that this dramatic reduction of infested area is partly a result of the 2009 tsunami, but it cannot be the whole reason because *A. gracilipes* was not detected within previously infested areas well above the tsunami-affected zone.

The maximum rate of spread determined from the only reliable measure, being the comparison of the western boundary of the Vini beach population between the October 2010 and May 2011 samples, was 20 m. It is assumed here that population expansion is negligible between April and October in Samoa, and thus consistent with this ant's population dynamics globally, thus the figure of 20 m is the current maximum annual figure. This distance is well below the expansion rates of well established populations (> 10 years old) which can disperse more than 100 m per year (Haines & Haines 1978), but is consistent with the expected expansion rate of a population approximately six years old (Hoffmann unpublished data).

Figure 2. Locations where *A. gracilipes* was detected (red points) or not detected (blue points) using visual inspections. Shading indicates areas that were assessed, but where GPS locations could not be obtained. Note: because GPS signal was often difficult to maintain under the vegetation canopy, many GPS points overlay each other and thus don't accurately display their continual dispersion throughout assessed areas.

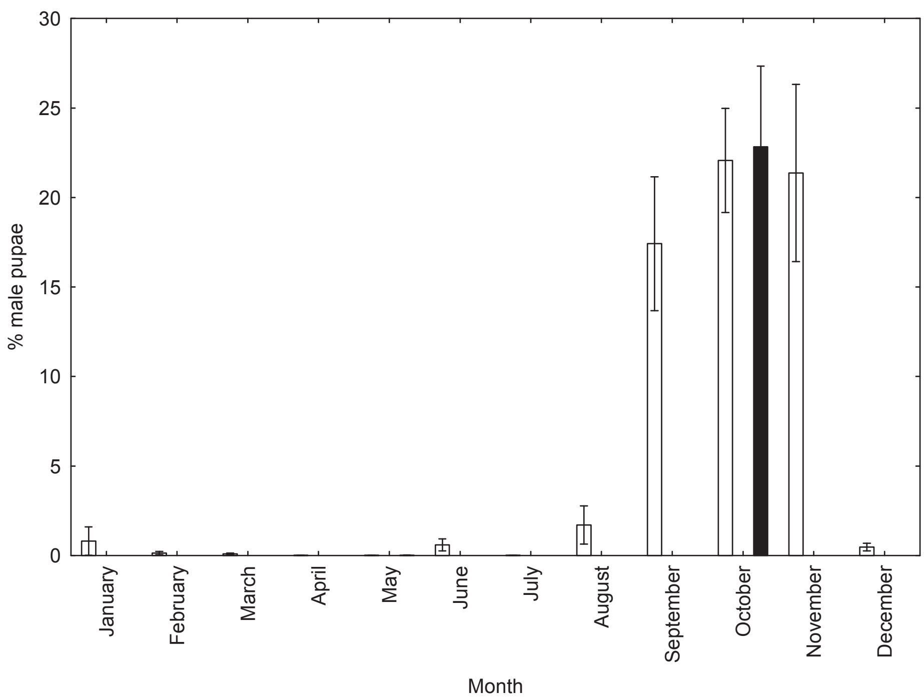


Overall, the significant decline in the Nu'utele beach population, the clear rise of other greatly dispersed populations, as well as the detection and subsequent absence of isolated nests suggests that *A. gracilipes* populations on Nu'utele are undergoing substantial flux.

3.2 REPRODUCTIVE PHENOLOGY

The unfortunate lack of monthly sampling means that little can be confirmed about *A. gracilipes* reproductive phenology in Samoa, but there are two noteworthy points. First, male reproduction patterns in Samoa appear to be consistent with places elsewhere globally, with the relative abundance of male pupae in October and May being extremely similar to that recorded in Arnhem Land, Australia in the same period (Figure 3), and October being within the period of male reproduction recorded from many places throughout the world. Only a single male pupa was found in the May sample from 4224 pupae collected.

Figure 3. Proportion of male pupae collected from monthly nest samples of pupae in Arnhem Land, Australia (grey bars) and Nu'utuele (black bar). Note: December data for Arnhem Land are incomplete, and only a single male pupa was found in the May sample from Samoa.



Second, such patterns for male reproduction are not consistent for queen reproduction. The only queen pupae that was collected was from a nest excavated in May, which is outside of the known reproductive period for this species, and none were excavated in October, which was when queen reproduction was anticipated to occur. The determination of the timing of queen reproduction remains as an important requirement for any management decision because treatment should be timed around the queen reproductive phase.

2.3 ANNUAL ABUNDANCE CYCLE

The unfortunate lack of monthly sampling means that the complete *A. gracilipes* annual abundance cycle in Samoa cannot be shown, but clear and expected trends are apparent. Worker counts on cards and tuna lures confirmed the expectation that worker abundance would be greatest in the May sample. Abundance from card counts was on average 30 ants in October, compared to 83 in May. The average abundance score from tuna lures was 4 (being between 11-20 ants) in October and over 7 (> 100 ants) in May. As a comparison, high-density crazy ant populations on Christmas island are defined as where ant abundance exceeds 38 in card counts. Thus *A. gracilipes* population levels on Nu'utele during their times of high abundance are as great as those seen on Christmas Island, but fall below this critical level during the time of low abundance. As a further comparison, within Nhulunbuy, Australia, card counts rarely exceed 38, and are on average only 17.

From pupal samples it is clear that the abundance levels from Samoa are much greater than those from Arnhem Land, Australia during comparable time periods, and it appears likely that there is also a difference in the period of greatest ant abundance with pupal abundance increasing earlier in Samoa than in Arnhem Land (Figure 4).

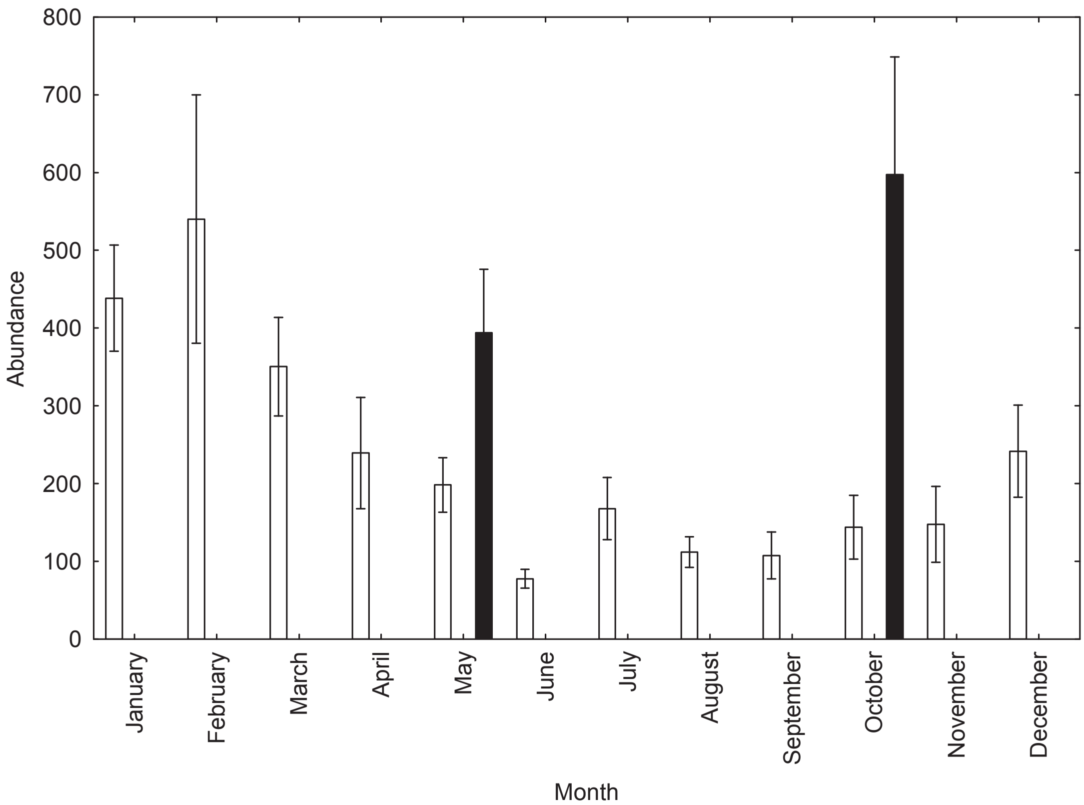


Figure 4 . Average monthly abundance of *A. gracilipes* pupae per nest sample in Arnhem Land, Australia (open bars) and Nu'utele (black bar). Note: December data for Arnhem Land are incomplete.

3.4 ANNUAL NEST DENSITY CYCLE

Because monthly sampling was not conducted, the exact annual cycle of nest density cannot be demonstrated. However, nest densities quantified in the two sample times conformed to expectations, with the nest density being greater in May when population levels were also greater.

The four plots from the October sampling contained 6, 2, 5 and 6 nests respectively. The plot containing only two nests is considered to be atypical as it was within a stand of *Pisonia grandis*, which is known to be unfavourable for invasive ants (Gerlach 2004; Hoffmann & Kay 2009). Therefore, excluding this plot, the average nest density was one per 4.4 m2. The nest density within the four differently located plots in the May sample was approximately double of that in October, containing 17, 12, 10 and 7 nests respectively, equating to an average nest density of one per 2.2 m^2.

This nest density on Nu'utele is among the highest recorded throughout the world. In the Seychelles, maximum nest density was one per 14.9 m2, none being underground (Haines and Haines 1978a). In comparable rainforest habitat in Arnhem Land *A. gracilipes* nest densities were one per 6.3 m2 (Hoffmann unpublished data). In New Guinea coconut palm plantations, Young (1996) found *A. gracilipes* ephemeral nests in leaf litter could occur up to one per 2 m2. Finally, on Christmas island, Abbott (2005) found nest entrance densities reached 10.5 per m2, however at this density these entrances would not constitute discrete nests. Indeed what constitutes a discrete nest within the high density populations on Christmas Island is not clear (personal observation).

3.5 IMPACTS

3.5.1 Ants in pitfall traps

A total of 24 ant species from 15 genera were collected within pitfall traps within both sampling times, 18 species from 13 genera within the 2010 sample and 20 species from 13 genera within the 2011 sample (Appendix 1). The most abundant species (excluding *A. gracilipes*) were *Pheidole umbonata* (46.2% of total abundance of all species excluding *A. gracilipes* within both sample times), the exotic tramp *Paratrechina longicornis* (18.6%), *Odontomachus simillimus* (17.4%) and another exotic tramp, *Tetramorium bicarinatum* (7.2%). The relative contribution of these four species was very similar between the two sample times.

Anoplolepis gracilipes abundance within the infested plots was always much greater than the abundance of all other ants combined, being 7.6 and 5.9 times greater than native ant abundance within infested and uninfested plots respectively in the 2010 sample, and 2.7 and 3.5 times greater respectively in the 2011 sample (Figure 5), with these differences being statistically significantly in all cases (Tables 1, 2). Interestingly, *A. gracilipes* abundance within pitfall traps was lower within the May sample, not greater as found by card counts and tuna lures, but this is solely due to an exceptionally large number of *A. gracilipes* (815) falling into a single trap within the 2010 sample, presumably because the trap was placed directly beside a nest.

Other ant abundance was not statistically different between infested and uninfested plots in both sample times (Figure 5, Table 2). However, other ant abundance was dominated by a single species, *Pheidole umbonata* (51% and 44% in the 2010 and 2011 samples respectively), and with this species excluded from analysis, other ant abundance was significantly lower within the infested plots (average 5 ants per plot) compared to the uninfested plots (11 ants) within the 2010 sample, and lower albeit not significantly (15 vs 19 ants) in the 2011 sample (Figure 6, Table 2). This lack of significance in the 2011 sample is predominantly attributable to a very high number of *Tetramorium bicarinatum* (48 ants) caught within a single trap, presumably placed beside a nest, but even with this trap removed, the difference between the two sites remained statistically insignificant (Mann-Whitney U-test, P = 0.08).

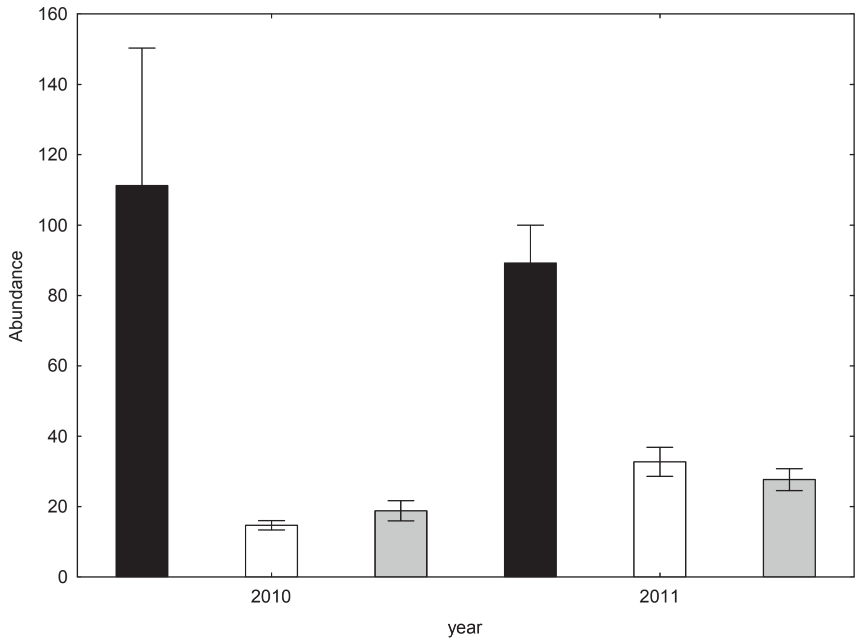


Figure 5. Mean (± SE) *Anoplolepis gracilipes* abundance (black bar) and the abundance of all other ants within plots in the infested site (white bar) and uninfested site (grey bar) within pitfall traps during the 2010 and 2011 sampling periods.

Table 1. Results of Wilcoxon matched pairs T-tests for comparisons of *A. gracilipes* abundance vs native ant abundance within infested plots, for the two sample times. Bold indicates significance of P < 0.025.

Sample time	T	z	P
2010 sample	0	3.92	**< 0.0001**
2011 sample	0	3.72	**< 0.0002**

Table 2. Results of Mann-Whitney U-tests of ant pitfall trap data between infested and uninfested plots for the two sample times. Bold indicates significance of P < 0.025.

	U	z	P
2010 sample			
A. gracilipes abundance vs other ant abundance	27	4.667	**< 0.0001**
Non-*A. gracilipes* ant abundance	175.5	-0.649	0.516
Ant species richness excluding *A. gracilipes*	166	0.906	0.365
Non-*A. gracilipes* ant abundance excluding *Pheidole umbonata*	92	-2.91	**0.0035**
2011 sample			
A. gracilipes abundance vs other ant abundance	35.5	4.21	**< 0.0001**
Non-*A. gracilipes* ant abundance	157	0.658	0.511
Ant species richness excluding *A. gracilipes*	27.5	4.444	**< 0.0001**
Non-*A. gracilipes* ant abundance excluding *Pheidole umbonata*	124	-1.623	0.105

Ant species richness per plot, excluding *A. gracilipes*, was always greater within the infested site, statistically significantly so in the 2011 sample (Table 2), having an average of six species per plot in the infested site vs three in the uninfested site. The greater species richness in the infested plot in the 2011 sample was predominantly due to other native ant species rather than other exotic species (8 species vs 4 respectively). A total of 14 species were found within the infested site and 11 in the uninfested site in the 2010 sample, and 18 vs 7 in the 2011 sample.

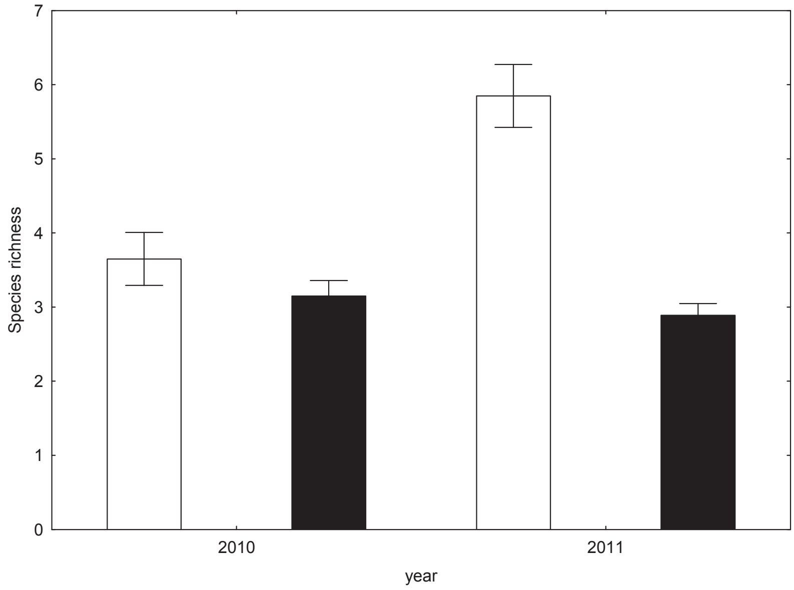


Figure 7. Mean (± SE) ant species richness, excluding *Anoplolepis gracilipes*, within plots in the infested (white bar) and uninfested site (black bar) within pitfall traps during the 2010 and 2011 sampling periods.

3.5.2 Ants in foliage beats

Nine ant species from seven genera were collected within foliage beats of both sample times combined, with the 2010 and 2011 samples each having only seven species (Appendix 1). Excluding *A. gracilipes*, four exotic tramps comprised 86% of total abundance within both samples combined, being *Tapinoma melanocephalum* (39%), *Paratrechina longicornis* (23%), *Monomorium floricola* (19%) and *Tetramorium bicarinatum* (5%). The contribution of these species within the two sample times varied greatly, with that of *Paratrechina longicornis* being 34% and 9% in the 2010 and 2011 samples respectively, 31% and 6% respectively for *Monomorium floricola*, 28% and 52% for *Tapinoma melanocephalum*, and 0% and 12% for *Tetramorium bicarinatum*.

Within the infested site the abundance of other ants was 2.6 and 1.8 times greater than that of *A. gracilipes* in the 2010 and 2011 samples respectively, (Figure 8), but these differences were not statistically significant (Wilcoxon matched pairs T-test, T = 14.5, z = 1.325, P = 0.185 for 2010 and T = 17, z = 1.423, P = 0.155 for 2011) due to great variation among the samples. Similarly, other ant abundance within the uninfested site was not statistically different from *A. gracilipes* abundance in the infested site in the 2010 sample, but was statistically greater in the 2011 sample (Figure 8, Table 3). There was no significant difference between the abundance or species richness of other ants between the infested and uninfested sites in both sample times (Figures 8, 9; Table 3).

Figure 8. Mean (± SE) *Anoplolepis gracilipes* abundance (black bar) and the abundance of all other ants (white bar) in the infested site (white bar) and uninfested site (grey bar) within foliage beats during the 2010 and 2011 sampling periods.

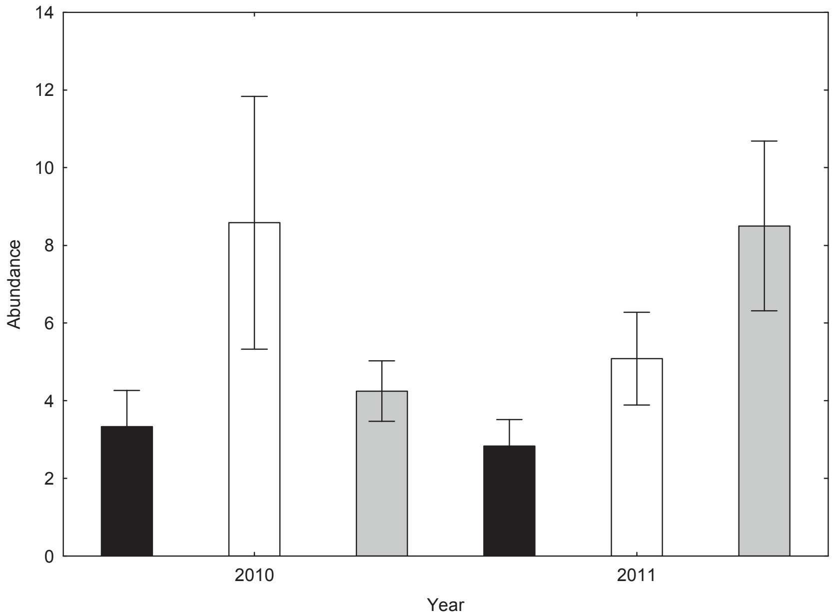
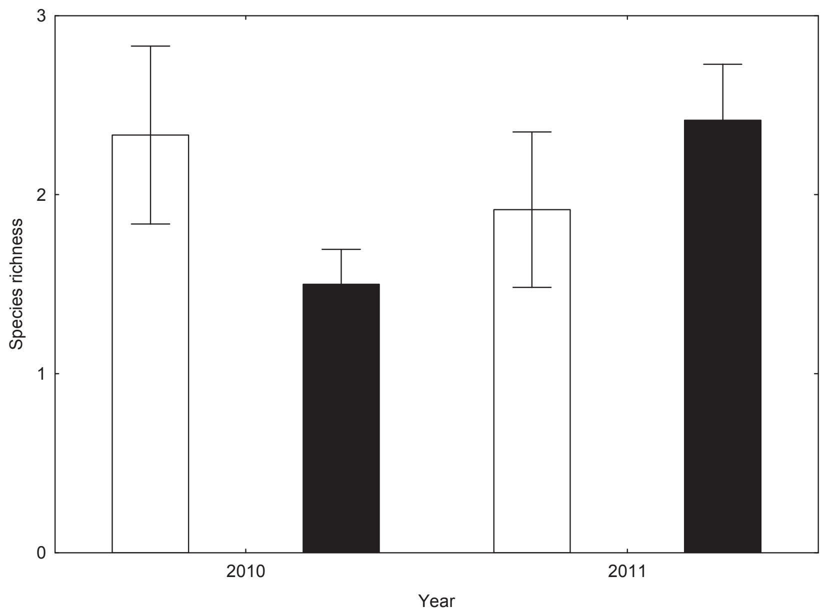


Table 3. Results of Mann-Whitney U-tests of ant foliage beat data between infested and uninfested plots. Bold indicates significance of P < 0.025.

	U	z	P
2010 sample			
A. gracilipes abundance vs other ant abundance	59	-0.722	0.466
Non-*A. gracilipes* ant abundance	64	0.433	0.665
Ant species richness excluding *A. gracilipes*	51	1.184	0.237
2011 sample			
A. gracilipes abundance vs other ant abundance	31	-2.338	**0.019**
Non-*A. gracilipes* ant abundance	54.5	-0.981	0.326
Ant species richness excluding *A. gracilipes*	54.5	-0.981	0.326

Figure 9. Mean (± SE) ant species richness, excluding *Anoplolepis gracilipes*, within foliage beats in the infested (black bar) and uninfested site (white bar) during the 2010 and 2011 sampling periods.



2.5.3 Other macro-invertebrates in pitfall traps

Other macro-invertebrates from 11 orders were collected in pitfall traps. Flies were the predominate group collected (46% of all samples combined), followed by isopods (14%), moths and butterflies (8%) and crickets (7%) (Figure 10). There was no difference in the overall abundance or ordinal richness of other macro-invertebrates between the infested and uninfested sites within any of the two sample times (Figures 11, 12, Table 4). Variation in the abundance of individual orders both between sites and between sample times is present (Figure 10), but most specimens were capable of flight and thus are highly mobile, so such variation (at least within such a small infested area) should be interpreted with caution. The exception are spiders (Arachnida) and isopods (Isopoda) which are relatively sedentary, and are well known to be sensitive to exotic ant invasions.

There were consistently fewer spiders within the infested site (5 vs 18 individuals in 2010 and 2 vs 16 in 2011), however, because of the imposed lower level of probability for statistical significance (P = 0.025) these differences were only statistically significant in the 2011 sample (Table 4). Consistent with research globally, there were more isopods in the infested site in both sample times, but the differences were not statistically significant (Table 4).

Table 4. Results of Mann-Whitney U-tests of other macro-invertebrate data from pitfall traps between infested and uninfested plots in the 2010 and 2011 samples. Bold indicates significance of P < 0.025.

	U	z	P
2010 sample			
total abundance	196	-0.09	0.924
ordinal richness	164	0.96	0.337
Spider abundance	124.5	-2.03	0.042
Isopod abundance	139.5	1.62	0.105
2011 sample			
total abundance	109	2.06	0.039
ordinal richness	178	-0.03	0.977
Spider abundance	74	-3.08	**0.002**
Isopod abundance	178.5	0.029	0.977

3.5.3 Other macro-invertebrates in foliage beats

Other macro-invertebrates from eight orders were collected in foliage beats. Spiders were the predominate group collected (37% of all samples combined), followed by crickets (21%), and beetles (14%) (Figure 13). The variation in the abundance of most individual orders is not addressed here because of the mobility of the fauna. However, for spiders (Arachnida) which are both relatively sedentary and well known to be sensitive to exotic ant invasions, there is a clearly fewer individuals within the infested site in both sample times, and this abundance difference was statistically significant in the 2011 sample (Table 4). This difference in spider abundance had no effect on combined macro-invertebrate data, and just as for pitfall trap data there was no difference in overall abundance or ordinal richness between the infested and uninfested sites within either of the two sample times (Figures 14, 15, Table 5).

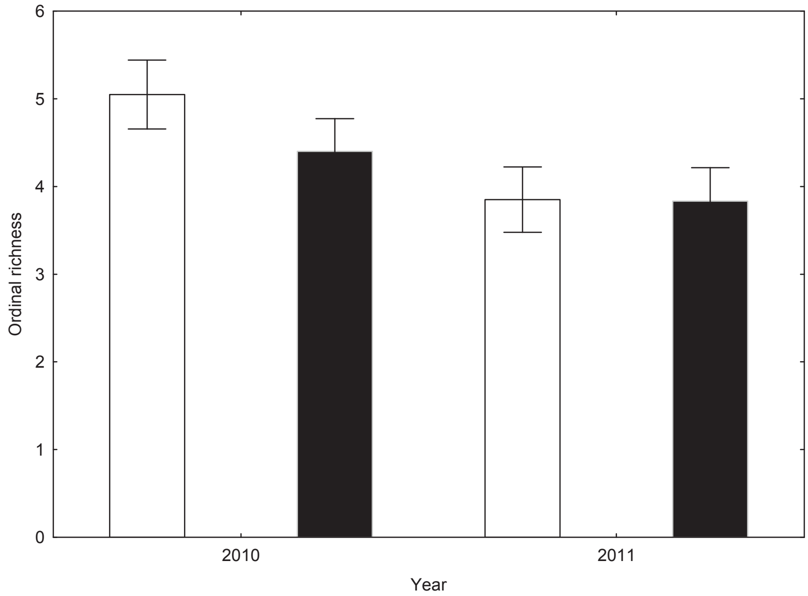


Figure 12. Mean (± SE) other macro-invertebrate ordinal richness within foliage beats in the infested (white bar) and uninfested site (black bar) during the 2010 and 2011 sampling periods.

3.5.4 Hermit crab counts

There was a clear difference in total hermit crab abundance between infested and uninfested sites in both sample times. In the 2010 sample, when *A. gracilipes* abundance was lowest, the infested site had approximately one quarter of the crabs per plot (average = 1.3 ± 0.43) of the uninfested site (average = 5.3 ± 1.62), being greatly statistically different; Mann-Whitney U Test: U = 104, Z = -2.5, P = 0.0098. This statistical result was driven by large crabs (Mann-Whitney U test: U = 98.5, Z = 2.73, P = 0.0063) as there were too few small crabs collected to produce a statistical difference in this size class (Mann-Whitney U test: U = 179.5, Z = -0.54, P = 0.5885). Only seven small crabs were found in the infested site compared to 28 in the uninfested site, but the proportion of small crabs to the total count was consistent between the two sites (27% and 26% respectively), indicating that any factor affecting hermit crab abundance applied equally to both size classes.

The difference in crab abundance between the infested and uninfested sites were even more pronounced in the 2011 sample when *A. gracilipes* abundance was greater, with only four large crabs being found in the infested site, compared to an average of 2.7 crabs per sample in the uninfested site. Naturally this difference was highly statistically significant (Mann-Whitney U Test: U = 34, Z = -4.477, P < 0.0001).

3.6 PHYTOPHAGOUS INSECTS AND EXTRAFLORAL NECTAR

Multiple unidentified species of scale and at least one mealy bug species were found on six tree species (Table 3). The only interaction noticed between *A. gracilipes* and these insects was with scales on Indian Mulberry (Nonu) *Morinda citrifolia*, but all of the insect species were found within the infested areas.

Six plant species were found to have extra floral nectaries or carbohydrate sources accessible to ants (Table 3), but *A. gracilipes* was found attending these sources only on the Indian Mulberry (Nonu) *Morinda citrifolia*.

There was a marked difference in the abundance of extrafloral nectar sources between the infested and uninfested sites. Within the infested site, 50% and 32% (average of 41%) of the trees sampled along the two transects had EFNs, being approximately double than that within the uninfested site (17% and 34% respectively, average of 26%). This difference was not attributable to a single species, with four of the six species being encountered more within the infested site. Similarly, the occurrence of phytophagous insects differed greatly between the two sites, with 24% and 33%

respectively (average of 29%) of assessable trees within the infested site harbouring phytophagous insects compared to only 7% and 0% (average of 4%) within the uninfested site. The abundance of phytophagous insects were also clearly different between the two sites, with those in the infested site predominantly occurring as clusters of many individuals, whereas only two individual scales were found within the uninfested site on two trees.

It is not possible to state whether the current distribution of *A. gracilipes* solely at the north-eastern end of Vini beach is a consequence of the vegetation composition (and hence EFN availability), or if this distribution is merely by chance and in time the ant will infest the entire beach. Similarly, it is unclear whether the phytophagous insect density is a cause or consequence of the *A. gracilipes* distribution. However, carbohydrate sources from both plants and phytophagous insects are well-known drivers of invasive ant abundance, and interestingly the greatest ant diversity was also found within the infested site where carbohydrate sources were greatest. Such a deterministic relationship has never been demonstrated before between invasive ants and vegetation composition, and thus this is an exciting observation worthy of further investigation.

Table 3. Plants with extra floral nectar sources and phytophagous insects observed on Nu'utele, as well as observed interactions with *A. gracilipes.*

Scientific name	Samoan name	English name	Description	*A. gracilipes* interaction observed
Plants				
Morinda citrifolia	Nonu	Indian Mulberry	Nectar supply at floral inserts on fruit	Yes
Passiflora foetida	Pāsio vao	Passionfruit	EFN location unclear, but *Passiflora* known to have EFN	No
Passiflora sp.	Pāsio	Passionfruit	EFN location unclear, but *Passiflora* known to have EFN	No
Terminalia catappa	Talie	Tropical almond	EFN pair at base of leaf	No
Macaranga harveyana	Lau pata		EFN at base of leaf	No
Hibiscus tiliaceus	Fau	Beach hibiscus	EFNs at base of leaf	No
Insects				
		Mealy bug	Found on *Barringtonia asiatica* (Futu), *Cocos nucifera* (coconut, Niu), *Mikanika micrantha* (Fue Saina), *Omalanthus nutans* (Mamala),	No Only mealy bugs on *Cocos nucifera* were within the infested areas
		scale	Found on *Barringtonia asiatica* (Futu), *Macaranga harveyana* (Lau pata), *Morinda citrifolia* (Nonu), unidentified tree	Yes on *Morinda citrifolia*, no for all others. Scales on *Macaranga harveyana* were within an uninfested area

Plants

Morinda citrifolia Nonu Indian Mulberry Nectar supply at floral inserts on fruit Yes *Passiflora foetida* Pāsio vao Passionfruit EFN location unclear, but *Passiflora* known to have EFN No *Passiflora* sp. Pāsio Passionfruit EFN location unclear, but *Passiflora* known to have EFN No *Terminalia catappa* Talie Tropical almond EFN pair at base of leaf No *Macaranga harveyana* Lau pata EFN at base of leaf No *Hibiscus tiliaceus* Fau Beach hibiscus EFNs at base of leaf No

Insects

Mealy bug Found on *Barringtonia asiatica* (Futu), *Cocos nucifera* No (coconut, Niu), *Mikanika micrantha* (Fue Saina), Only mealy bugs on *Cocos nucifera Omalanthus nutans* (Mamala), were within the infested areas scale Found on *Barringtonia asiatica* (Futu), *Macaranga* Yes on *Morinda citrifolia*, no for all *harveyana* (Lau pata), *Morinda citrifolia* (Nonu), others. Scales on *Macaranga* unidentified tree *harveyana* were within an uninfested area.

4. Management implications

The presence of *A. gracilipes* on the Aleipata islands is potentially of great concern, given the conservation significance of the islands, as well as the global reputation of this ant for its negative and often severe ecological impacts. Indeed the abundance levels and nest densities of this ant found in the surveys are among the highest recorded in the world. However, this did not translate directly into clear impacts for anything other than hermit crabs, and large ants such as *Odontomachus simillimus*. Importantly, this invasion is within an establishment phase when impacts are very localised and restricted to relatively sedentary or slow fauna, thus as the invasion expands and matures effects could be expected to increase, especially for more mobile fauna such as other invertebrates, birds and reptiles. However, the *A. gracilipes* populations on Nu'utele do not appear to be establishing well, and it remains unclear if any population on Nu'utele will be self-sustaining for more than a few years. Rather than expanding, the original population at Nu'utele beach appears to have been almost completely extirpated by natural causes, and two other populations along the walking trail disappeared altogether during the timeframe of this study. Also, between the two sampling periods the rate of expansion of the Vini beach population was quite negligible (20 m at maximum).

Should the impacts of an invader be determined to be great enough to consider management of the species, the decision to apply management actions or not should be dependent upon five criteria: 1) technical possibility; 2) practical feasibility; 3) environmental acceptability of treatments; 4) economic sensibility; and 5) political and social acceptability. Economic, political and social factors are not discussed here, as these are issues outside of the scope of this study.

Controlling and even eradicating *A. gracilipes* is definitely technically possible, as it has now been confirmed eradicated from 30 locations around the world (Hoffmann et al. in press; Hoffmann unpublished data), and ongoing efforts on Christmas island are well documented to be highly successful for short-term control (Green et al. 2004, 2009). Management actions on Nu'utele could also be argued to be feasible, depending upon the goal and area. Not all terrain on Nu'utele, including some infested areas, are accessible, thus any ground-based actions are only feasible for short-term management. However, aerial operations are feasible for broad scale treatments anywhere over the island, potentially for an eradication attempt.

The environmental acceptability of treatments is probably the greatest issue for *A. gracilipes* management on Nu'utele, and any other island ecosystem. Currently, all ant baits that are efficacious against *A. gracilipes*, also negatively affect land crabs (Wegmann 2008), marine invertebrates and many other ants. Whilst the impacts on marine invertebrates are presumably negligible (if at all) due to the dilution effect of the sea, treatment effects on land crabs and native ants can be greater than the impact of *A. gracilipes*, and this would be especially so if an entire island was to be treated multiple times for an eradication attempt. All but one *A. gracilipes* eradications to date have been achieved on mainland systems with no non-target issues, and there are no published details about the sole eradication that was achieved on a part of an island within the Seychelles (Haines & Haines 1978). There is no doubt that broad-scale treatments using toxic bait over Nu'utele would have a significant impact on the island's hermit crabs (Wegmann 2008), and may well cause the local extinction of the coconut crab (*Birgus latro*). Unfortunately, the product with the least non-target issues (Distance), which utilises an Insect Growth Regulator rather than a toxicant, has thus far only achieved high levels of control rather than eradication, even after five treatments over two years within trials in Arnhem Land. Thus there is currently no product that can safely remove *A. gracilipes* from Nu'utele without causing significant environmental impact.

5. Management recommendations

Considering holistically the great flux of *A. gracilipes* populations, the restricted impacts, the great likelihood of severe non-target impacts from broad-scale baiting and the impossibility of conducting hand-treatments over all infested terrain, I do not recommend eradication from the island as a management goal. However, I do consider it feasible to at least suppress the spread and establishment of *A. gracilipes* on Nu'utele by conducting treatments aimed at locally eradicating the small populations on Nu'utele beach and on the western ridge, and to contain the population on Vini beach so that it does not further infest the lowland area. Such management would re-contain the ant to a single location, thereby suppressing its ability to completely establish over the island, and restrict its impacts to a single and small area.

Containment also provides better scope for complete eradication in the event that a treatment product is developed that can achieve eradication without inducing severe non-target impacts.

6. Research recommendations

Regardless of whether control measures are implemented or not, I highly recommend the continuation of some research conducted here, as well as additional research into other aspects of *A. gracilipes* biology, to address its invasiveness and potential management.

First, monthly sampling of crazy ant nest contents (e.g. pupae counts, queen counts) and nest density should be continued to fill the knowledge gaps of the biology of the ant, especially to determine the timing of queens reproduction. Such information is critical for effective management, and should be known prior to any broad-scale management operation, because treatments should be timed around the queen reproductive phase.

Second, the distribution of the ant should be monitored annually to bi-annually to either ensure that management actions are achieving their goals or to re-assess its status and risk on the island.

Third, additional research should be instigated to address the apparent relationship found between *A. gracilipes* distribution and the supply of carbohydrate resources from both plants and phytophagous insects. Such a deterministic relationship (if it really does exist) has never been demonstrated before between invasive ants and vegetation composition, and thus this is an exciting observation worthy of further investigation. For example, if a strong correlation was found to exist, then the distribution *A. gracilipes* within any area could be predicted based on vegetation composition. This research would require comparative work to be conducted on Nu'ulua, where *A. gracilipes* seems to be well-established island-wide (Vanderwoude et al. 2006). Any such work would also be best designed with an impact component to elucidate any relationship between vegetation composition, *A. gracilipes* abundance and ecological impacts.

7. Acknowledgements

Thanks to Alan Tye from SPREP for organising this work, and Saronna Auina for fieldwork assistance and processing the pitfall trap and foliage beat samples. Thanks also to MNRE staff for field assistance, especially Moemu Uili and Nola Talaepa, Niualuga, Davey, Kim, Lemi and Malua. I'm also grateful to Margaret Stanley and Darren Ward who provided oversight of the invertebrate sorting and identification. This work was funded by a grant to SPREP from the Critical Ecosystem Partnership Fund.

8. References

Abbott KL (2006) Delimiting survey of a yellow crazy ant infestation, and pretreatment monitoring set-up on Nu'utele Island, Aleipata, Samoa. Consultancy Report to the Secretariat of the Pacific Regional Environment Programme and the Samoan Ministry of Natural Resources and Environment. Monash University, Melbourne.

Drescher J, Blüthgen N, Feldhaar H (2007) Population structure and intraspecific aggression in the invasive ant species *Anoplolepis gracilipes* in Malaysian Borneo. *Molecular Ecology* 16:1453-1465.

Gerlach J. (2004) Impact of the invasive crazy ant Anoplolepis gracilipes on Bird Island, Seychelles. Journal of Insect Conservation 8:15-25.

Green P, Comport S, Slip D (2004) The management and control of the invasive alien crazy ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean: The aerial baiting campaign September 2002. *Report to Environment Australia and the crazy ant steering committee*. Monash University, Melbourne.

Green PT, O'Dowd DJ (2009) Management of invasive invertebrates: lessons from the management of an invasive alien ant. In: (MN Clout and PA Williams eds) *Invasive species management: a handbook of principles and techniques*. Oxford University Press, Oxford. pp 153-172.

Gruber AM, Hoffmann BD, Ritchie PA, Lester PJ (in press) Recent behavioural and population genetic divergence of an invasive ant in a novel environment. *Diversity and Distributions*

Haines IH, Haines JB (1978) Colony structure, seasonality and food-requirements of crazy ant. Ecological Entomology 3:109-118.

Hoffmann B, Davis P, Gott K, Jennings C, Joe S, Krushelnycky P, Miller R, Webb G, Widmer M (in press) Improving ant eradications: details of more successes, a global synthesis, and recommendations. *Aliens*

Hoffmann BD, Kay A (2009) *Pisonia grandis* monocultures limit the spread of an invasive ant – a case of carbohydrate quality? *Biological Invasions* 11:1403-1410.

Hoffmann BD, Saul WC (2010) Yellow crazy ant (*Anoplolepis gracilipes*) invasions within undisturbed mainland Australian habitats: no support for biotic resistance hypothesis. *Biological Invasions* 12:3093-3108

Hölldobler B, Wilson EO (1990) The Ants. Belknap Press, Massachusetts.

Hurlbert SH (1984) Pseudoreplication and the design of ecological field experiments. *Ecological Monographs* 54:187-211.

Krushelnycky PD, Gillespie RG (2008) Compositional and functional stability of arthropod communities in the face of ant invasions. *Ecological Applications* 18:1547-1562.

Vanderwoude, C, Siolo S, Sio F, Tupufia S (2006) Assessment of Yellow Crazy Ants (*Anoplolepis gracilipes*) on Nuulua Island, Aleipata, Samoa with recommendations for population control. Consultancy report to the Samoan Ministry of Natural Resources and Environment.

Wegmann A (2008) Land crab interference with eradication projects: Phase I compendium of available information. Pacific Invasives Initiative, the University of Auckland, New Zealand.

Appendix 1

ANT SPECIES FOUND WITHIN THE INFESTED (I) AND UNINFESTED (U) SITES IN THE 2010 AND 2011 SAMPLING PERIODS WITHIN PITFALL TRAPS AND FOLIAGE BEATS.

Species	Classification	Pitfall traps				Foliage beats			
		2010 I	2010 U	2011 I	2011 U	2010 I	2010 U	2011 I	2011 U
Anochetus graeffei	Native	X	X						
Anoplolepis gracilipes	Exotic	X	X	X		X		X	
Brachymyrmex obscurior	Native	X							
Camponatus sp. *maculatus* group	Native			X					
Hypoponera punctatissima	Native	X	X	X	X				
Monomorium destructor	Exotic		X						
Monomorium floricola	Exotic	X		X		X	X	X	X
Monomorium pharaonis	Exotic		X						
Odontomachus simillimus	Native	X	X	X	X				
Oligomymrex atomus	Native				X				
Paratrechina longicornis	Exotic	X	X	X	X	X	X	X	X
Pheidole fervens	Native			X					
Pheidole oceania	Native	X		X			X		
Pheidole sexspinosa	Native	X		X					
Pheidole umbonata	Native	X	X	X	X	X		X	X
Rogeria stigmatica	Native	X	X	X					
Rogeria sublevinodis	Native			X					
Strumigenys rogeri	Native	X	X	X	X				
Tapinoma melanocephalum	Exotic	X	X	X	X	X	X	X	X
Technomyrmex vitiensis	Native			X					X
Tetramorium bicarinatum	Exotic	X	X	X				X	
Tetramorium lanuginosum	Exotic	X		X					
Tetramorium pacificum	Native			X			X		
Tetramorium simillimum	Exotic			X					

CEPF Large Grant Final Project Completion Report

Restoration of Nu'utele and Nu'ulua Islands (Aleipata Group), Samoa

Organization Legal Name

Secretariat of the Pacific Regional Environment Programme

Project Title

Restoration of Nu'utele and Nu'ulua Islands (Aleipata Group), Samoa, through the management of introduced rats and ants

Date of Report

8 May 2012

Report Author and Contact Information

This report was written and compiled by Alan Tye from field, lab and progress reports and published articles written by the project team (see References).

All photos by Alan Tye unless otherwise credited.

Contact:

Dr Alan Tye, BirdLife Cyprus, PO Box 28076, Nicosia, CY-2090, Cyprus. (During the course of this project, Invasive Species Advisor, SPREP.)

alantye@gmail.com

CEPF Region

Polynesia-Micronesia Hotspot

Strategic Direction

Strategic Direction 1: 'To prevent, control and eradicate invasive species in key biodiversity areas' and in particular 1.2. 'Control or eradicate invasive species in key biodiversity areas, particularly where they threaten native species with extinction.'

Grant Amount

US$ 227,898 (amount spent: US$ 223,040.48).

Project Dates

1 May 2009 to 31 Dec 2011

Implementation Partners for this Project

The project was managed by SPREP's Invasive Species Advisor (Dr Alan Tye)

Original partners listed in the project proposal

Ministry of Natural Resources & Environment, Government of Samoa (MNRE) (main staff contributions). MNRE was the main government partner charged with implementing most aspects of the project. MNRE allocated staff mainly from its Environment and Conservation division, who participated in all seven Components of the project, including planning, field work and community liaison. Staff particularly involved in the project included: Moeumu Uili, Czarina Iese, Fialelei, Lesaisaea Niualuga Evaimalo, and Faleafaga Toni Tipama'a (Assistant CEO, Environment and Conservation, MNRE).

Pacific Invasives Initiative (PII) (training). PII provided biosecurity training to MNRE and Marine Protected Area staff and local communities. PII contributed to the development of a biosecurity manual and visitors' checklist.

Department of Conservation, New Zealand (aerial operations). DOC provided a helicopter operations supervisor (Malcolm Wylie), who managed the technical aspects of the helicopter operations. DOC also contributed an environmental impact assessment of the rat eradication plan (Scott Hooson), and to project planning and review (DOC Island Eradication Advisory Group). Rose Collen assisted with Ground Dove capture and maintenance in captivity.

David Butler Associates Ltd (project technical coordination). David Butler managed Components 1 and 2, parts of Component 4, and contributed to the other Components.

Zoos (Ground Dove work). Wellington Zoo provided specialist aviculture volunteers (Glenn Holland and Bronwyn McCulloch) who supervised Ground Dove capture, maintenance in captivity and release.

PILN (dissemination, exchanges). PILN disseminated information on the project to a network of more than 400 invasive species workers in the Pacific.

US Geological Survey (lizard monitoring). Dr Robert Fisher designed and carried out reptile surveys before and after the rat eradication operation.

JICA (cofinancing aviary design). JICA contributed to the design of the aviaries used to house the Friendly Ground Doves.

ADDITIONAL PARTNERS WHO CONTRIBUTED SIGNIFICANTLY TO THE PROJECT

Aleipata District Marine Protected Area Committee (Chair: Seuala Patone). The village communities of the District were involved in the project since the outset, participating in field activities and discussions within the MPA Committee. They also approved the rat eradication EIA.

Dr Ben Hoffmann, CSIRO, Darwin, Australia. Designed and implemented the final version of Component 3.

University of Auckland. Research student Saronna Auina, a Samoan national, was engaged to work with Ben Hoffmann on the Yellow Crazy Ant, under the supervision of Dr Margaret Stanley.

ADDITIONAL ACKNOWLEDGMENTS

Glenn Holland, Richard Parrish and Greg Sherley contributed to Component 2 and to bird recording on the islands; Northshore Helicopters (NZ) were contracted to carry out the helicopter operation; rat bait was supplied by Animal Control Products (NZ); Cedric Schuster carried out bird counts (for Component 4).

Conservation Impacts

Please explain/describe how your project has contributed to the implementation of the CEPF ecosystem profile

Please refer to Project Summary detail in PART 1 of this publication.

Please summarize the overall results/impact of your project against the expected results detailed in the approved proposal

Planned Long-term Impacts - 3+ years (as stated in the approved proposal):

Nu'utele and Nu'ulua Islands, Aleipata Group, are restored as key sites for the conservation of Samoa's indigenous biodiversity. The native fauna and flora have shown dramatic improvements in populations after being released from the impact of introduced pests, and further species have been introduced to the islands to ensure their conservation. Nu'utele Island is used for small-scale ecotourism under the MPA umbrella and benefiting its traditional owners and the people of the District. Nu'ulua Island is a largely unvisited wildlife sanctuary.

Actual Progress Toward Long-term Impacts at Completion:

It is too soon to assess the long-term impacts of this project fully, but these may be summarised as follows:

1. Rat eradication. Rats have been detected on Nu'utele Island, following the eradication attempt. We do not know whether these are survivors of the eradication or reinvaders. Survival might have been favoured by high densities of crabs burying bait quickly, while reinvaders might have been assisted by the September 2009 tsunami. We hope that this question may be resolved by future DNA analysis of rat populations, and a future plan (another eradication attempt or not) will depend to some extent on the results of these analyses.

2. Island restoration. Even though rats are on Nu'utele, the temporary reduction in their population permitted an escape of seedling regeneration which will have a lasting effect on future forest structure. Regeneration had been impeded by predation on seeds and seedlings, and there is now a cohort of saplings ready to serve as replacement and reinforcement of the populations of native forest trees. This would not have occurred without the eradication attempt, and its effects will last for decades.

3. Nu'ulua. It has been impossible to resurvey Nu'ulua fully since a few days after the eradication attempt, so we do not know whether rats still occur on the island. It is hoped to resolve this question by helicopter-assisted survey in May 2012.

4. Yellow Crazy Ant. The work carried out by this project provides the basis for an eventual realistic management plan. It is hoped that Dr Ben Hoffmann will continue work on the islands and contribute to such a plan.

Planned Short-term Impacts - 1 to 3 years (as stated in the approved proposal):

Following the removal of rats and control of yellow crazy ants, a recovery of native plants and animals has been documented by monitoring. Friendly ground doves have been returned to the Nu'utele and are increasing in number. A biosecurity programme is active to minimise the risks of these and other pests invading.

Actual Progress Toward Short-term Impacts at Completion:

1. Biosecurity. The local communities and MNRE staff were trained in suitable biosecurity measures for the islands, and these were temporarily implemented. However, procedures are no longer being followed.

2. Bird populations. Bird populations seem to have benefited from the reduced rat population, although if rat populations reach their pre-eradication levels, the bird populations are expected to return also to their pre-eradication levels.

3. For other aspects of recovery, see Long-term impacts above.

Please provide the following information where relevant

- *Hectares Protected*:

108 (Nu'utele) and 25 (Nu'ulua).

- *Species Conserved*: N/A

This was an ecosystem-focused project. However, the following IUCN threatened species benefited: Friendly Ground Dove Gallicolumba stairi (VU); Tooth-billed Pigeon Didunculus strigirostris (EN); Hawksbill Turtle Eretmochelys imbricata (CR); Coconut Crab Birgus latro (DD).

- *Corridors Created*: N/A

Describe the success or challenges of the project toward achieving its short-term and long-term impact objectives

Successes and shortcomings are described above and are summarised under individual components, below. Challenges and steps taken to overcome them are described under Lessons Learnt, below.

Were there any unexpected impacts (positive or negative)?

None noted that was directly attributable to the project.

Project Components

Project Components: Please report on results by project component. Reporting should reference specific products/deliverables from the approved project design and other relevant information.

COMPONENT 1 PLANNED

Pacific rats (Rattus exulans) are eradicated from Nu'utele and Nu'ulua Islands by aerial delivery of toxic baits.

COMPONENT 1 ACTUAL AT COMPLETION:

It is not yet known whether rats were eradicated on either island. Rats are present now on Nu'utele, but it is not clear whether these are survivors of the operation or re-invaders. It is unlikely that Pacific Rats would swim the distance from Upolu to Nu'utele, but the tsunami in September 2009, just after the eradication operation, washed up large quantities of debris on the island, on which rats could have floated. Samples were collected for DNA analysis to try to determine whether the rats now on the island are survivors or re-invaders, but these were lost by the courier company contracted to send them to the lab in Auckland. Further sampling is planned for May 2012.

It has not been possible to survey Nu'ulua since August 2009, just after the rat operation. No rats were detected then, but a further survey is needed to confirm this. The survey is planned for May 2012.

COMPONENT 2 PLANNED

Friendly ground doves (Gallicolumba stairii) protected by capture and transfer from Nu'utele to a temporary facility and return to the island after the poisoning operation.

COMPONENT 2 ACTUAL AT COMPLETION

Successfully completed.

COMPONENT 3 PLANNED

Consultancy to CSIRO for ant work.

Yellow crazy ants are either managed or researched, according to information acquired during first year of project. Research focuses on biology and impacts and the results are used to prepare a management plan.

COMPONENT 3 ACTUAL AT COMPLETION

Research on biology and impacts was carried out, although more needs to be done before a detailed management plan can be prepared. Management recommendations include not to attempt eradication, although on Nu'utele, suppression of the Vini Beach population and local eradication of the Nu'utele Beach and western ridge populations are feasible.

COMPONENT 4 PLANNED

Changes in native flora and fauna following removal of pests are monitored.

COMPONENT 4 ACTUAL AT COMPLETION

This component was only partially successful, largely due to inconsistency of sampling techniques and lack of reports from some contributors. Best results were obtained for vegetation photo-points.

COMPONENT 5 PLANNED

Increase awareness of project and its benefits within Aleipata communities and ensure their involvement.

COMPONENT 5 ACTUAL AT COMPLETION

Community support was in general good, and liaison with the communities worked well, despite the effects of the 2009 tsunami on Aleipata District. However, the latter caused delays or inability to complete some of the formal community relations exercises planned.

COMPONENT 6 PLANNED

A biosecurity programme is established with the aim of preventing the reintroduction of rats (all Rattus spp.), ants and other invasive species to the islands following the project.

COMPONENT 6 ACTUAL AT COMPLETION

Training was completed and a biosecurity manual and visitors guide written. A community-led biosecurity inspection system was put in place, but was has since been abandoned by MNRE and the communities. A monitoring and response system was partly established, but it has not been possible for MNRE to maintain it.

COMPONENT 7 PLANNED

Project results are written up and shared widely in region.

COMPONENT 7 ACTUAL AT COMPLETION:

Mostly completed, except for the planned project video. Further publications are expected.

Were any components unrealized? If so, how has this affected the overall impact of the project?

No component was entirely unrealized, however, some did not fully achieve the results expected of them, as follows:

Component 1: Eradication of Pacific Rats. The detection of rats on Nu'utele after completion of the eradication attempt was a disappointment, and the reason for the presence of rats is not yet known, as discussed above. However, the project resulted in a release of forest regeneration and of populations of some animals, and the long-term effects of this will be positive for the island ecosystem.

Component 3: Management of Yellow Crazy Ants. The ant studies provided valuable information needed to produce a rational management plan, but part of the study, intended to have been carried out by MNRE staff, was not done. Before a management plan is written, further information is required on suitable bait-toxin mixes and on ant biology on the islands.

Component 4: Monitoring ecosystem response. No reports on the reptile monitoring were provided by the consultant recruited to do this work, Dr Robert Fisher. The bird monitoring programme was insufficiently sensitive to determine modest population changes, although if continued and refined it could provide valuable data. Vegetation plots established by MNRE were not maintained and data were lost, but photopoints provide some record of vegetational changes.

Component 6: Biosecurity. The community-managed biosecurity system for the islands was not maintained. Biosecurity is no better than before the project, and further pest incursions to the islands may be expected. A monitoring and rapid-response system, to be operated by MNRE, has not been established.

Component 7: Dissemination of results. The planned project video was not produced, although extensive footage of project activities was taken and remains available.

MNRE has included follow-up on some components of this project in its activities financed by the GEF-funded Pacific Alliance for Sustainability project "Prevention, control and management of invasive alien species in the Pacific Islands". This includes further monitoring for rats, other invasives and ecosystem response on the islands.

Please describe and submit (electronically if possible) any tools, products, or methodologies that resulted from this project or contributed to the results.

This was one of the first helicopter-delivered rat eradication attempts on islands of Oceania, and the first in Polynesia. The Ground Dove holding techniques were to some extent experimental.

The ant work should contribute to the development of management techniques useful for Yellow Crazy Ant control, within and outside Samoa. The biosecurity documents would be useful if applied locally and serve as guides for the development of similar documents for other sites.

Lessons Learned

Describe any lessons learned during the design and implementation of the project, as well as any related to organizational development and capacity building. Consider lessons that would inform projects designed or implemented by your organization or others, as well as lessons that might be considered by the global conservation community.

Project Design Process: (aspects of the project design that contributed to its success/shortcomings)

A major factor contributing to success was the recruitment of key advisors for several of the components, including an overall operations supervisor for Components 1, 2 and 4 (David Butler), an aerial operations advisor (Malcolm Wylie) and an expert on Yellow Crazy Ant (Ben Hoffmann).

Some of the project's activities were not achieved owing to lack of completion of commitments by other project staff and advisors. This applied to parts of Component 3 (monthly ant monitoring), Component 4 (reptile, bird and vegetation monitoring) and Component 6 (implementation and maintenance of biosecurity inspections, long-term monitoring and rapid response). Capacity loss due to staff turnover at the main government partner agency contributed to this.

Further details on these points may be found in Butler et al. (2011).

Project Implementation: (aspects of the project execution that contributed to its success/shortcomings)

Based on our experience contracting a helicopter company, it is not sufficient to rely on one company that appears to be in a 'preferred supplier' position; a tender process should always be run to ensure back-ups in case situations change.

Based on experience with bait supply, if timing is tight, it would be worth drafting major supply contracts with suppliers at the point that funding looks assured rather than after it is approved. This would allow more time to address any conflicting issues.

A period of at least four months should be allowed between the confirmation of funding and an operation of the complexity of the rat eradication, to allow sufficient time for the process of tendering, testing equipment and assembling it on site.

Always build in at least one week's contingency for shipping delays and issues releasing and unloading cargo.

Butler et al. (2011) discussed the many changes in Government personnel involved in the project which meant that advisors and managers had to take a greater role than expected in project activities. Support from MNRE's Division of Environment and Conservation was not as strong as expected. In particular the Marine Section did not provide the boat support it was committed to, despite the project providing it with an outboard engine for its MPA work. MNRE Terrestrial Division was also unable to carry out other aspects of the project work, discussed above, owing to loss of capacity due to staff turnover during the period of the project.

For further lessons learnt regarding the rat operation, see Butler et al. (2011).

Other lessons learned relevant to conservation community:

Although the rat eradication on Nu'utele was followed by the detection of rats on the island, the temporary reduction of the rat population produced a valuable pulse of forest regeneration.

Additional Funding

Provide details of any additional donors who supported this project and any funding secured for the project as a result of the CEPF grant or success of the project.

Donor	Type of Funding*	Amount	Notes
SPREP	A, in kind	$50,000	Invasive Species Advisor and communications staff time, financial and administrative support, office supplies and communications costs.
New Zealand Department of Conservation	A, in kind	$15,000	Staff time contributions.
Pacific Invasives Initiative	A, in kind	$10,000	Staff time for training and biosecurity document input
Pacific Invasives Learning Network	A, in kind	$5,000	PILN Coordinator staff time
Ministry of Natural Resources and the Environment, Samoa	A, in kind	$85,000	Staff time
Local Community	A, in kind	$500	Logistical support
US Geological Survey	A, in kind	$8,500	R. Fisher staff time
University of Auckland	A, in kind	$5,000	Staff time and support for ant work.
GEF	B	$25,000	For ant research and management and for invasives monitoring on the Aleipatas.

**Additional funding should be reported using the following categories:*

A Project co-financing (Other donors contribute to the direct costs of this CEPF project)

B Grantee and Partner leveraging (Other donors contribute to your organization or a partner organization as a direct result of successes with this CEPF project.)

C Regional/Portfolio leveraging (Other donors make large investments in a region because of CEPF investment or successes related to this project.)

The total cost of the project

This may be calculated as the amount of the grant spent ($223,040) plus the major costed in-kind contributions mentioned above (excluding the new funding from GEF), making a total cost of US$402,040.

Sustainability/Replicability

Summarize the success or challenge in achieving planned sustainability or replicability of project components or results.

The main challenges to sustainability were the inconsistent support provided by government and local community partners to different aspects of the project, as discussed above and under "Recommendations" below. However, the project clearly fell within the priorities of Samoa's National Invasive Species Action Plan (NISAP), and follow-up activities have been included by MNRE in its plans under the GEF-PAS Invasive Species project which began in 2012, including further monitoring on the islands and revision of Samoa's Emergency Response Plan to cover incursions more effectively.

The project is replicable, and several Pacific countries and territories are planning similar projects. Part of the value of the present project was therefore its clear identification of some of the challenges to undertaking this kind of work in Oceania, as discussed in this report and in Butler et al. (2011) and Hoffmann (2011).

Summarize any unplanned sustainability or replicability achieved.

N/A

Safeguard Policy Assessment

Provide a summary of the implementation of any required action toward the environmental and social safeguard policies within the project.

The toxin used for the rat eradication, brodifacoum, is toxic to vertebrates. Negative impacts have been recorded on some bird species that eat bait fragments. The project recognised that a few bird species common in the country, such as the Banded Rail, might suffer a few individuals killed, but the national populations would be unaffected. Both islands were surveyed a few days after the bait drops, to determine non-target impacts. Two dead Banded Rails were found, but many other live ones were seen, and the population of this species on the islands remains healthy. No other dead animals were seen except rats.

As described above, Friendly Ground Doves were removed to a temporary aviary and returned to the island once the baits had disappeared, but doves left on the islands were unharmed.

Additional Comments/Recommendations

This project was always envisaged as part of a longer-term programme for island restoration and maintenance. In this section some recommendations are given for the next steps towards this, organized according to the Components of the CEPF project.

1. RATS, PIGS AND FOWL

From our present state of knowledge, three stages are envisaged for the next steps in rat management on the islands:

Further research to discover whether rats are on Nu'ulua and whether those on Nu'utele are survivors or re-invaders.

Based on research results, decide on the most advisable future management (new management plan).

Securing funding and resources to implement the new plan.

Further research

Nu'ulua. The priority for Nu'ulua is to determine whether rats are present or absent. A thorough survey using a variety of detection methods should be carried out over several nights (minimum two nights). Leaving detection devices on the island and rechecking after four or five days would be an alternative acceptable means, or an additional step. This survey is planned to be carried out in May 2012, using a helicopter to drop and retrieve staff and equipment. In addition to traps and other detection devices, night searches should be undertaken, and other rat sign such as rat-chewed fruit should be looked for during the day. Any fruits found with chewed holes should be collected so that they can be examined by an expert to identify what was feeding on them. Walking slowly at night with powerful torches looking on the ground and up the lower parts of trees can detect rats through 'eye shine' or movement.

Detection devices to employ include Kamate aluminium and Victor wooden kill-traps, held by MNRE, with roasted coconut as bait. Tomahawk live traps can be set up to allow rats access and keep out crabs (fixed on platforms that crabs cannot reach, with a ramp placed with a gap between it and the trap that a rat can jump but a crab cannot reach across). Wax tags made from unscented candles melted in moulds and a lure added, such as coconut cream or grated coconut, are cheap and easy to produce in large quantities, and can be used to obtain good coverage over the whole island. Tags that have been chewed should be brought back for analysis. Traps and tags should generally be placed about chest height to be out of the reach of crabs. If lots of tags are available some could be placed lower as Nu'ulua appears to have few crabs. Sticky traps as used on reptile surveys by MNRE staff can be used to detect rat hair; staff experienced in using these would be able to detect rats and safely release any reptiles caught. Rodent Baiter stations (5-6 held at MNRE) can be nailed to small trees in a way that prevents crabs getting access to the entrances, and a variety of baits fixed inside. The presence of rats would be indicated by feeding on baits and by droppings found in the stations – they need to be opened carefully to catch any droppings.

If any detection devices show signs that rats are present, then traps should be moved to that area to try to catch them. Pieces of coconut can be placed on the ground around the trees with traps on to help attract rats.

If rats are detected on Nu'ulua, then the next steps would be as for Nu'utele, below. Rat tail samples should be obtained.

Nu'utele. The priority for Nu'utele is to obtain a new sample of rat tails for DNA analysis, to attempt to determine if they are survivors or re-invaders. Trapping should occur where rats have previously been caught, that is at Vini Beach and up the hill to the area where most rats were caught during the last survey. There is no need to go any further from Vini than the top of the ridge. Kamate and

Victor traps should be used (technique as above) until a enough have been collected. The ideal number is 20–30, but at least 10 are needed.

A tail sampling protocol is available on the PII website. One tail only should be placed in each vial with scissors or a small sharp knife wiped clean with alcohol between rats, so blood etc containing DNA cannot be mixed from one to another. There are plenty of vials at MNRE and 96% alcohol can be bought from Samoa Pharmacy. Rubbing alcohol (50%?) could be used as a substitute.

Upolu. More Pacific Rat tails need also to be collected from Upolu in Aleipata District (ideally 20–30, but at least 10). Several trap nights may be required because the other two species of rat are common there. The single Pacific Rat caught during the last visit was on a coconut tree by the beach, not in the bush on the inland side of the road. Some habitats might be more favourable for catching Pacific Rats, perhaps a plantation or the forest at the base of the cliff at Lalomanu.

DNA analysis. Send the samples to Ecogene (Auckland University, Tamaki Campus) for analysis.

Considerations for a new rat management plan

Detailed recommendations must await the results of DNA analyses. These could provide evidence on whether the rats on Nu'utele are survivors or new arrivals, or they may give no clear guidance. If the rats on Nu'utele and Upolu have sufficiently different DNA (consistent with a long period of isolation), it can be concluded that the rats now on Nu'utele survived the operation. If the DNA of the two rat populations is not that dissimilar, then we cannot conclude whether the rats now on Nu'utele are survivors or re-invaders.

If rats are found on Nu'ulua, this would suggest that rats survived the operation, since new arrivals are unlikely because few boats visit there (though the tsunami a complication). Rat DNA from Nu'ulua would permit comparison with Nu'utele and Upolu, providing additional evidence on whether rats on both islands are survivors or re-invaders.

Before a follow-up poisoning operation is considered, concerns over biosecurity and Government support need to be addressed (see below).

Pigs and domestic fowl

Pigs should be eradicated from Nu'utele as soon as possible. A hunting operation with shooters and dogs or traps would be most effective. Pig eradication is desirable on its own, irrespective of rats, as pigs can do major damage to the island (including to breeding Ground Doves). Although domestic fowl (feral chickens) may be less damaging, they will have impacts on invertebrates and lizards and they should also be eradicated. Eradication of pigs and fowl would be achievable at low cost with experienced personnel. It would be advisable to make this community driven, via the Sagapolutele family, as it would only be through the community that pigs and chickens could get back to the island. This could also be an opportunity to do further community advocacy work.

2. FRIENDLY GROUND DOVE

Feathers were collected for DNA analysis, to be sent to Mike Sorenson of Boston University msoren@bu.edu. This will be pursued by SPREP with Mike and with scientists in the Department of Marine and Wildlife Resources, American Samoa, who had proposed a study of genetic differentiation between the different populations of the species.

A system to monitor the populations of this species in the long term should be developed.

3. YELLOW CRAZY ANT

Monthly sampling of Yellow Crazy Ant nest contents and nest density should be continued to fill knowledge gaps on the biology of the ant, especially to determine the timing of queen production. Such information is critical for effective management, and should be known prior to any broad-scale management operation, because treatments should be timed around the queen reproductive phase. The distribution of the ant should be monitored annually to bi-annually, to ensure that management actions are achieving their goals or to re-assess the ant's status and risk on the island. Additional research should be instigated to address the apparent relationship found between Yellow Crazy Ant distribution and the supply of carbohydrate resources from both plants and phytophagous insects. The relationship found, between an invasive ant and vegetation composition, has never been demonstrated before, and might allow the distribution and impacts of Yellow Crazy Ant within any area to be predicted based on vegetation composition. This research would require comparative work on Nu'ulua, where the species is established island-wide.

Meanwhile, eradication from the island is not recommended as a management goal, in part because Yellow Crazy Ants are probably arriving relatively frequently on Nu'utele in boats and materials from Upolu. Suppression of the Vini Beach population and local eradication of the Nu'utele Beach and western ridge populations are feasible, although the suppression is likely to be temporary and the environmental impacts of repeated treatments by toxic baits need to be balanced against the impacts of the ants.

4. ECOSYSTEM MONITORING

Robert Fisher should be further encouraged to supply results and reports from his work on reptile monitoring.

An improved method of bird monitoring should be designed.

Periodic monitoring of reptiles, birds, vegetation and invertebrates should continue.

5: COMMUNITY RELATIONS AND GOVERNMENT SUPPORT

MNRE should continue to work closely with the MPA Committee and Aleipata District communities, to ensure the maintenance and enhancement of the biodiversity values of the islands.

Currently MNRE's Terrestrial Division has minimal field capacity and is not functioning strongly. Changes are needed before MNRE can play its full role in any future operation.

6. BIOSECURITY

The community-managed biosecurity system needs continuous support from MNRE if it is to become and remain functional. The biosecurity manual and visitors' checklist should be printed and distributed to the MPA and local communities, and should also be adhered to and enforced by MNRE.

A long-term surveillance programme should be established on Nu'ulua and Nu'utele, to detect new pest incursions. A rapid-response system needs to be developed to deal with incursions detected. Outline plans for these are included in the biosecurity manual.

As part of the long-term pest surveillance system, rat detection devices should be left on Nu'ulua if no rats are detected there in May 2012. 'Storm' rodent baits (available from Farm Supplies) should be wrapped in aluminium foil and placed (ideally wired) in the Rodent Baiter bait stations. Kamate traps can be left nailed to trees with long-life baits. A line(s) of bait stations and traps should be set up in the forest on the flat behind the beach with devices 50 paces apart.

Information Sharing and CEPF Policy

CEPF is committed to transparent operations and to helping civil society groups share experiences, lessons learned, and results. Final project completion reports are made available on our website, www.cepf.net*, and publicized in our newsletter and other communications.*

Full contact details:

Name: Name: Dr Alan Tye

Organization name: BirdLife Cyprus

Mailing address: PO Box 28076, Nicosia, CY-2090, Cyprus

Tel: +357 22 455072

Fax: +357 22 455073

E-mail: alantye@gmail.com

CONSERVATION
INTERNATIONAL

Pacific Islands

BIODIVERSITY
CONSERVATION
LESSONS LEARNED
TECHNICAL SERIES

13