# INVASIVE SPECIES BASELINE SURVEYS & FEASIBILITY STUDIES, HUVALU FOREST, NIUE.

## REPORT FOR MINISTRY OF NATURAL RESOURCES, NIUE

**Dr David J Butler, R&D Environmental Ltd, Nelson, New Zealand**

**MARCH 2016**

## Contents

## 1.0 Introduction

This report was prepared as one of the outputs of the GEF PAS project "Prevention, eradication and control of invasive alien species in the Pacific islands" funded by the Global Environment Facility (GEF), implemented by the United Nations Environment Programme (UNEP) and executed by Secretariat of the Pacific Regional Environment Programme (SPREP) in partnership with the Department of Agriculture, Forestry and Fisheries of Niue (DAFF). It was designed to contribute to two activities in Niue's programme within this project:

1. *Develop and establish long term monitoring and GIS for areas with important native biodiversity that may be impacted by invasives.*

Huvalu Conservation Area, which is the subject of a project within the Regional Forestry and Protected Areas Management Project (FPAM), was identified as the key area for survey.

2. *Conduct a pilot feasibility study for ten priority weed or vertebrate eradication targets.*

This project was to include consideration of yellow crazy ants (*Anoplolepis gracilipes*) (are they there, where and what could be done about protecting the forest from them?) and rats and feral cats (what options are there for their management?). Feral pig management is being undertaken as a separate activity within the GEF-PAS project.

The delivery of the project was affected by Cyclone Tuni (category 1) which passed close to Niue on 29th November with c.75km/h winds. There was little damage to the island's infrastructure but noticeable impact in the forests with a thick carpet of leaves and small branches and trees down. The strength of the winds made it too hazardous to work in the forest on the first day, and a significant effort was needed to clear the key Vinivini Track of windfalls over the next couple of days. There would have been some effect on the mammals being surveyed – e.g. an abundance of fruit on the forest floor for rats – and the leaf carpet made it impossible to detect some field signs – e.g. cat droppings.

The survey was designed as follows;

1. Rats – to begin by undertaking trapping along the Vinivini Track from the inland end, repeating 3-day surveys undertaken in 1994 (Powlesland & Hay 1995) and 2004 (Powlesland, Butler & Westbrooke 2006) and establish a pattern of ship rat and Pacific rat activity. To set out small corflute™ plastic tags in between the traps baited with wax lured with coconut oil and peanut butter, to calibrate chewing of tags with trapping. This would then enable many more tags to be put out to assess rat activity around a wider area.
2. Yellow Crazy Ants – to set out commercially formulated baits on laminated paper cards, beginning with the inland end of the Vinivini Track where they had been detected on previous surveys. This allowed the effectiveness of the baits and the time that should be allowed before they are re-checked (allowing enough time to detect ants but not so long that the baits dry out and become unattractive) to be determined in a known YCA area. Baits would then be set out on a widespread basis using roads and bush tracks around and inside Huvalu Forest.
3. Feral cats and feral pigs – sightings of any individuals and their droppings or feeding sign were to be recorded during the other surveys and specific night-time drive-through surveys carried out.
4. Weeds – records were to be kept of any sightings of the weeds species targeted by the project and any new ones of concern.

## Visit schedule

The field team consisted of Huggard Tongatule, the GEF-PAS Invasive Species Coordinator, and David Butler assisted on different days by several Niue locals.

**Mon 30/11/15** – Office (meetings DAFF and DOE) and drove to Vinivini Track to assess damage – trees down on track and too dangerous for work in forest with post-Cyclone Tuni winds.

**Tues 1/12** – Set out 20 rat traps on Vinivini track – as previous surveys – and set out and checked ant baits.

**Wed 2/12** – Staff meeting. Checked and re-set 20 rat traps. Set and checked ant baits, set out rat tags and chain-sawing to access more of Vinivini Track

**Thurs 3/12** - Checked and re-set 20 rat traps. Checked rat tags and chainsawing to access all of Vinivini Track. Set and checked ant baits on Vinivini, Lalotavahi, Fulala & Pagopago Tracks.

**Fri 4/12*** – (DB only) Checked & collected 20 rat traps, checked rat tags Vinivini. Delimiting surveys for yellow crazy ant around start of Vinivini.

**Mon 7/12** – Rat & ant surveys Vaile Track to secondary forest, Togo Track, ant surveys road to Liku.

**Tues 8/12** - Checked Vaile & Togo track rat traps, ant & rat survey Liku Seatrack, Vakulu Track.

**Wed  9/12** - Checked Liku Seatrack and Vakulu Track traps, ant survey roadsides.

**Thurs 10/12** – Ant surveys roadsides.

**Fri 9/12*** – DB only – data analysis.

**Note:** Government staff in Niue work a 4-day week.

**Photo: Removing a large windfall on Vinivini Track**

**Photo: DAFF team and windfalls in secondary forest, Vinivini Track.**

**Photo: Leaves and fruit littering Vinivini Track following Cyclone Tuni**

## 2.0 Methods

### Rat surveys

20 Striker snap traps (RC-507-1) supplied by Connovation Ltd, NZ were set out at 200m intervals in vegetation alongside Vinivini Track (as the methodology in Powlesland & Hay (1995)) and baited with roasted coconut and peanut butter. They were checked and re-baited nightly for three fine nights. Following this survey they were used overnight at a variety of different sites.

Plastic tags (c5x2cm) were created using corflute with the gaps in the plastic filled with peanut butter (melted slightly to flow into the gaps) or wax (melted) with coconut oil lure and nailed to trees a short distance off the ground in vegetation beside roads and tracks. Initially two separate tags with the different baits were used but these were later combined in the one tag.

**Photo: Striker rat trap (baited and set) and kuma**

**Photo: Base of wax tag showing interference by crabs.**

## Ant surveys

Non-toxic 'INFORM' [1]ant baits supplied as paste in caulking gun cartridges were applied as 1cm lengths on to laminated white cards set out on the ground under the shade of vegetation. The main targets of the survey were yellow crazy ants which are known to be a significant conservation concern. The baits contain both protein and carbohydrate and are designed to attract a wide range of ant species so several were located and collected in 70% ethanol. Five trial baits were set out by the shelter at the start of the Vinivini Track and significant numbers of YCA were present on each after a few minutes. Fifteen minutes was set as the minimum period that a bait had to be left before checking though on some surveys this extended to over an hour. Overall, 166 baits were set out on tracks and road edges

[1] Supplied by Merchento, PO Box 2256, Stoke, Nelson, New Zealand.

around and within Huvalu Forest, most at 200m intervals. A delimiting survey was carried out around the inland start of the Vinivini Track with 64 baits placed at intervals of 25 paces (c. 20 metres).

### Weed surveys

On each survey the team looked for a range of priority weeds that were targeted for control elsewhere.

### Feral cat and feral pig surveys

Any sightings of pigs and cats or their droppings or feeding sign were recorded. One dusk/night drive-through survey was conducted on Vinivini Track (once it had been cleared of windfalls) and the road between there and Alofi.

### Bird observations

Counts of two species, the veka or banded rail (*Gallirallus philippensis*) and pekapeka or white-rumped swiftlet (*Collocalia spodiopygia*) were undertaken on road surveys by car as done in 1994 and 2004, counting each individual seen and summarising the data as birds per kilometre.

## 3.0 Results

Tables 1 and 2 summarise the rat trapping data.

**Table 1: Rat trapping – Vinivini – 60 trap nights.**

| Date | Captures | Sprung empty | Unsprung |
|---|---|---|---|
| 3/12/15 | 3 (1 Pacific, 2 ship rat) | 5 | 12 |
| 4/12/15 | 4 (4 ship rat) | 5 | 11 |
| 5/12/15 | 2 (2 ship rat) | 2 | 16 |
| **Total** | **9 (1 Pacific, 8 ship rat)** | **12** | **39** |

**Table 2: Rat trapping – Vaile, Liku (Seatrack), Vakulu, Togo Tracks – 22 trap nights.**

| Date | Captures | Sprung empty | Unsprung |
|---|---|---|---|
| 7/12/15 | 1 (Pacific)* | - | - |
| 8/12/15 | 3( 1 Pacific, 2 ship rat) | 0 | 7 |
| 9/12/15 | 2 (Pacific) | 7 | 3 |
| **Total** | **6 (4 Pacific, 2 ship rat)** | **7** | **10** |

* Caught on return walk c. 1 hour after trap set – other traps not checked

**Ant baiting**

Yellow crazy ants (YCAs) were recorded in patches alongside several sections of road and bush tracks around Huvalu Forest (Table3) (Figure 1).

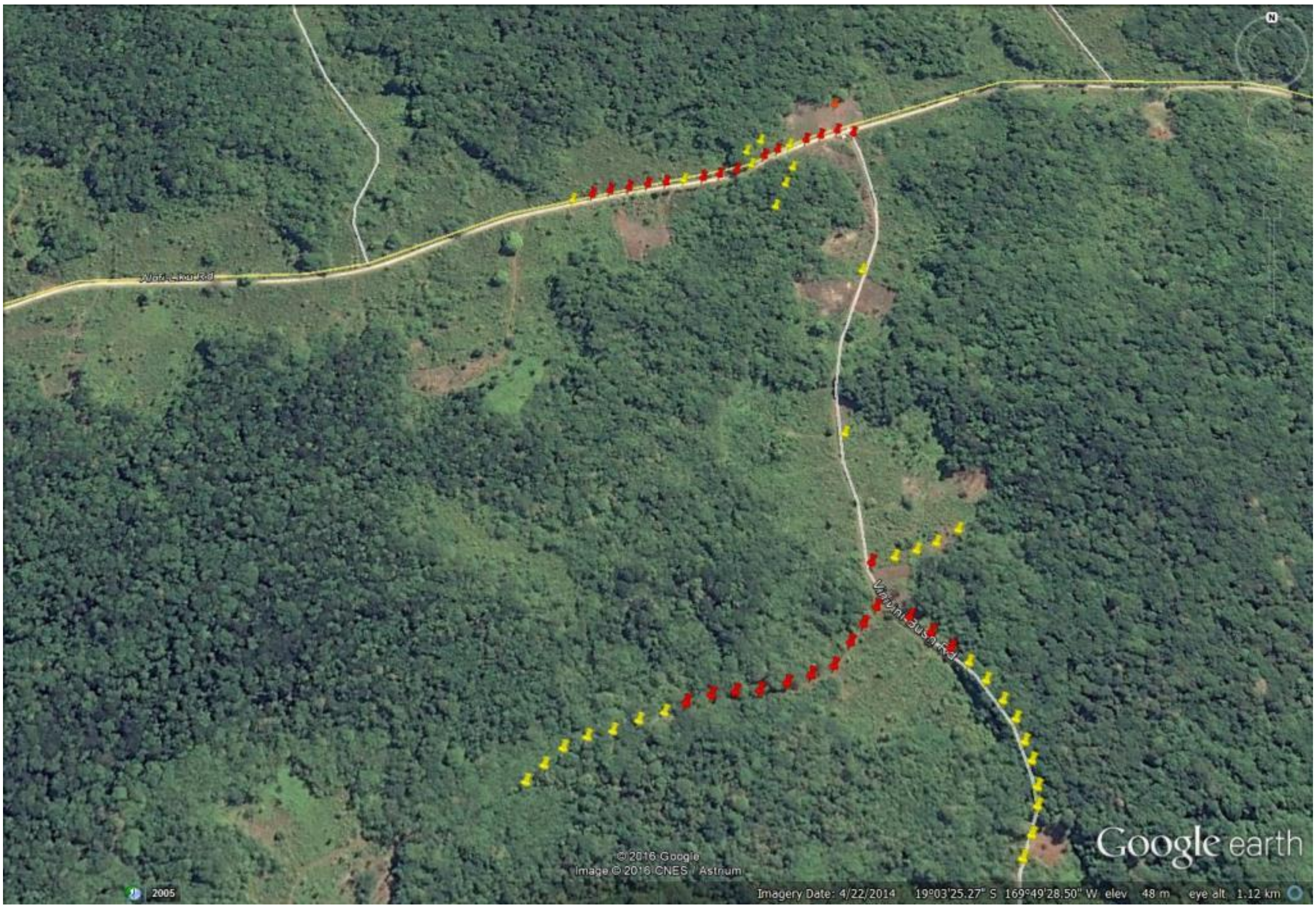
**Table 3: Summary of YCA ant baiting results**

| Site | Baits with YCA | Baits with no YCA |
|---|---|---|
| Vinivini Track | 1 (inland start) | 19 |
| Lalotavahi Track | 0 | 8 |
| Fulala Track | 0 | 5 |
| Pagopago Track | 4 | 14 |
| Vaile Track | 9 | 0 |
| Liku Sea Track | 1 | 7 |
| Vakulu Track | 0 | 11 |
| Togo Track | 0 | 6 |
| Road – Liku to Hakupu | 3 | 27 |
| Road – Vinivini start to Liku | 3 | 14 |
| Road – Vinivini start towards Alofi | 4 | 6 |

**Figure 1: Map of ant baiting sites – red flag or red number denote those where YCA were found.**

A brief delimiting survey was carried out around the shelter at the inland start of the Vinivini Track to gauge the extent of the infestation in that area (Figure 2). It suggests that the ants are confined to quite a small area within the forest and scrub but extend further in patches along the roadside towards Alofi.

**Figure 2: Ant survey around start of Vinivini Track. Baits placed 20m apart.**
**Red: YCA's present. Yellow: no YCA's.**




Where YCA's were present they tended to dominate baits to the exclusion of most other ants (Figure ?). In particular their presence was strongly correlated with the absence of the large black ant known locally as ***lotoga (****Odontomachus simillimus*) (Table 4).

**Table 4: Presence and absence of YCA and lotoga on baits**

| **Ants present** | YCA & *lotoga* | YCA and no *lotoga* | *Lotoga* and no YCA | Neither species |
|---|---|---|---|---|
| **No. of bait cards** | 1* | 46 | 41 | 138 |

* A single ant of each species

Photo: c.60 YCA's on bait card

## Weed Surveys

The main tracks and roadsides had previously been surveyed for weeds. No significant new weed observations were made on these. *Scindapsis* was seen at a rubbish dump on the Lalotavahi Track.

## Feral Cat Surveys

A drive-through survey of Vivinivini Track on 4/12 beginning on dusk (6.30pm) yielded no sightings of feral cats or pigs. The large amount of leaf debris on tracks following the cyclone made it impossible to record droppings or 'kills' as possible measures of activity.

## Bird Observations

Table 5 shows that pekapeka were only detected on the lower roads and all eight sightings were actually made on a single early evening trip from Alofi to Tamakautoga around the coast. Only one bird was seen in the three days of work along the Vinivini Track.

**Table 5: Counts of pekapeka and veka made while driving.**

| Road Classification | Km travelled | No. of pekapeka | No. of veka |
|---|---|---|---|
| Lower | 72.5 | 8 | 2 |
| Inland | 230.8 | 0 | 1 |
| Upper | 20.4 | 0 | 0 |

No hega were sighted during this work and key nectar sources were not seen to be flowering at this time. I did receive an email from Larry Burrows of Landcare Research who has been conducting forest surveys in Huvalu. He got good views of a pair of birds flying behind Teresa's Guesthouse in Alofi in November 2015 and from what he wrote I am almost certain that these were hega.

## Lizard observations

We observed few skinks as conditions were generally overcast. However it seems worth documenting that a tourist reported seeing a large lizard in 2015 on the track to Talava Arches (Huggard Tongatule pers. comm.) that sounds like it may have been the very rare olive small-scaled skink (*Emoia lawesi*).

# 4.0 Discussion

## Rat monitoring

Rat trapping proved an effective technique that allowed comparison with previous surveys and provided some data on the relative numbers and distribution/habitat use of the two species. Wax tags were largely untouched for several possible reasons.

### Trapping

The 2015 Vinivini Track results are compared with those of 1994 (Powlesland & Hay 1995) and 2004 (Powlesland, Butler & Westbrooke 2006) in table 6 below and the capture rates are broadly similar.

**Table 6: Vinivini trapping results, 1994, 2004, 2015.**

| **Survey Date** | **Captures (rate/100 trap nights[2])** | |
|---|---|---|
| | **Ship Rat** | **Pacific Rat** |
| December 1994 | 13 (20.3) | 1 (1.6) |
| September 2004 | 6 (12.5) | 3 (6.25) |
| December 2015 | 8 (16.2) | 1 (2.0) |

Rats were also caught in small numbers on Vaile, Liku and Togo Tracks

As in the two previous surveys the Pacific rats were largely caught in areas of regenerating scrub, though also in this survey in coastal forest, whereas ship rats were caught in all habitats including secondary and primary forest.

**Table 7: Rat trapping results in different habitats.**

| **Species** | **Habitats** | | | | **Total** |
|---|---|---|---|---|---|
| | Regenerating scrub | Secondary forest | Primary forest | Coastal forest | |
| Ship Rat | 5 | 2 | 3 | 0 | 10 |
| Pacific Rat | 3 | 0 | 0* | 2* | 5 |

* One Pacific rat was caught on Togo coastal track in forest that could be classified as 'primary'.

### Wax tags

There was very limited chewing of wax tags, despite two baits being available (peanut butter and coconut oil/wax) which have proved attractive in my work elsewhere (e.g. New Zealand and Samoa). This therefore did not provide a useful guide to rat activity in different habitats and areas as hoped. The low result may have been related to Cyclone Tuni which deposited a lot of fruit on the ground throughout the forest at the start of the survey, or reflect generally low rat numbers, or possibility (but unlikely) that Niue rats have different food preferences.

[2] Corrected trap nights were calculated using the methodology of Cunningham & Moors (1996).

## Ant surveys

The surveys provided a useful picture of the distribution of yellow crazy ants in the vicinity of Huvalu Forest. They are found in patches but are present around many of the roads and tracks accessing the forest, suggesting that they have been moved around by the activities of people in these areas.

The possible response to these results is included in the Feasibility Assessment below.

## Feral cats

No viable technique to assess cat activity was found. The same problem exists in New Zealand where techniques have been developed to index populations of rodents and mustelids (stoats, etc) but where detecting cats proves challenging.

The question is whether feral cats are a significant problem that needs addressing? A suggested first step towards answering this would be to carry out a study of their diet, aimed at determining their relative impact on birds, rodents and other prey. Feral animals would need to be trapped or shot to provide stomach samples for analysis and their contents would need to be analysed by someone with appropriate expertise.

## Feral Pigs

Feral pigs are subject to a separate control and monitoring programme within the GEF-PAS Invasives project. We did not see any animals, and feeding sign observed fitted with the known pattern of animals favouring scrub and coconut areas rather than primary forest.

## Bird observations

The low number of pekapeka sightings on roadside surveys is considered a concern when compared with previous surveys (Table 8). Powlesland, R.G., D.J. Butler & I.M. Westbrooke (2006) identified that these surveys are not considered to be good measures of population status as numbers will vary significantly with the time of day and the weather. However the failure to detect any birds on inland and upper roads is considered significant. Weather conditions following Cyclone Tuni are not considered an explanation given the large number of birds seen on a section of coastal road.

Swiftlets nest in caves and forage over quite long distances. However these results raise the possibility that some inland colonies of swiftlet may have been reduced to very low numbers or become extinct. A national survey of cave fauna is identified as an action within Niue's revised National Biodiversity Strategy & Action Plan (NBSAP) and this is given additional emphasis by these results. It would hopefully identify some key breeding caves for swiftlets in Niue and allow their future to be monitored. It is possible that rats may have an impact on swiftlet populations through predation at nesting colonies.

**Table 8: Comparison of pekapeka seen on driving surveys, 1994, 2004, 2015.**

| Year | Pekapeka/km | | |
|---|---|---|---|
| | Lower | Inland | Upper |
| 1994 | 0.97 | 0.37 | 0.42 |
| 2004 | 0.43 | 0.56 | 0.11 |
| 2015 | 0.11 | 0 | 0 |

## 5.0 Assessment of the Feasibility & Benefits of Managing Rats

**Eradication**

The eradication of rats from Niue has been discussed occasionally. At 26,146 hectares Niue is more than twice the size of islands where rats have been successfully eradicated to date (Campbell Island 11,331ha, Macquarie Island 12,785ha). Both of these are uninhabited and in the sub-antarctic, whereas Niue is populated and in the tropics where rat eradication has proven more difficult (Russell & Holmes 2015). However it could theoretically be possible but very costly to eradicate rats from Niue, as there are now serious investigations to remove them from an island as large as Stewart Island (157,000 hectares) in New Zealand. Mice which are apparently present on Niue in low numbers and feral cats would probably also be eradicated by such an operation, so removing rats would not have negative outcomes in terms of increasing other key pests. Preventing rats re-invading should be feasible given that Niue has no port and goods are largely barged and lifted ashore in containers. However the benefits of eradication would not appear to justify the expense as rats and the other invasive mammals pose no real threat to peoples' livelihoods or health or only the olive small-scaled skink's could be considered a globally significant population.

**Control**

There are techniques available to reduce rat numbers to levels at which their damaging impacts on biodiversity are reduced. These typically involve providing poisoned bait in bait stations though self-resetting traps are showing some promise. There are a large number of projects in New Zealand controlling rats (usually ship rats), many run by community groups (Butler, Lindsay & Hunt 2015). In the Pacific Islands the longest running programme has been on Rarotonga, Cook Islands where a pilot rat-poisoning operation began in 1989 aimed at the recovery of the only population of the endemic kakerori or Rarotongan monarch whose numbers were down to less than 30 birds. This was expanded to c.750 bait stations over a 150+ hectare area and the impact on rats led to increased nesting success and survival so that the population reached 271 by 2007 by which time a new population had been established on a further island, Atiu (Robertson *et al*. 2009). The most recent population estimate was 380 birds in 2011 (BirdLife International 2016).

More recently numbers of a species of the same genus in French Polynesia, the Tahiti Monarch, have increased from 19 to over 50 birds through a combination of rat poisoning (ship and Pacific rats), banding nesting trees to prevent rat access and control of invasive myna birds.

Control programmes for rats have recently been initiated in two forest areas in Tonga, at Toloa Rainforest Preserve on Tongatapu and Mt Talau National Park in the Vava'u Group as a pilot programme for the country. Local communities are involved replacing the baits in bait stations and undertaking weed control. Bird counts were recently repeated in February 2016 a year after they were first done. They showed a limited response of bird populations in Toloa. This could be related to two issues, or a combination of the two. Firstly rats may not have been controlled consistently to low enough numbers as baiting was somewhat infrequent with most stations empty of bait when they came to be re-filled. Secondly the species particularly vulnerable to rats were only present in very low numbers so it would take some time for a detectable increase in their numbers to occur. However at Mt Talau the Tongan whistler *(Pachycephala jacquinoti)* which is endemic to Vava'u showed a significant response with average number of birds per count increasing from 0.78 in 2015 to 1.89 in 2016 (Butler 2016). There were also somewhat smaller increases of two species found in Niue, the Polynesian triller (*Lalage maculosa*) and Polynesian starling (*Aplonis tabuensis*) showing that these may also be subject to significant rat predation.

It seems likely that a bait station operation could similarly reduce rat numbers in an area on Niue and there are some standard procedures to follow. There is one native species, the misi or Polynesian starling that appears to be in decline with significantly fewer in one area in 2004 compared to 1994 (Powlesland et al. 2006), which may recover in numbers to judge by the Tongan result. The revised NBSAP suggests actions to assess the impact of rats on this species and monitoring the outcomes of a bait station operation could be one way to achieve this. Watling (2001) identified that most heahea, misi, kulukulu and lupe probably nest in mature forest. This is also where ship rats are found, the more significant nest predator of the two rat species, so it could be the area to target by any poisoning. Reducing rat numbers around pekapeka caves could be important for the survival of this species as discussed earlier.

It has been identified that two very rare species in Niue are likely to be vulnerable to rats, the hega or blue-crowned lory and the olive small-scaled skink. There have been no recent reports of these species in Huvalu though hega were seen there along the Vinivini Track in 2004. The very small number of recent, unconfirmed reports for both species has come from coastal areas on the west of the island.

While Niue has a limited number of native vertebrates, due largely to its isolation and small size, those that are present ate vitally important as co-adapted components of the country's forests whose disappearance would likely lead to some instability of the system. E.g. the loss of an insectivorous bird like the pekapeka could cause some insects populations to increase to the extent that they become a problem. Also every bird species contributes to the experience of visitors when there are only a small number found.

**Possible Trial Grid and Indicative Costs**

The recent work at Toloa and Mt Talau in Tonga provides the figures used in the following analysis. Toloa, an area of c23 hectares utilised 116 Protecta bait stations to achieve a 50m x 50m grid at a cost of c. NZ$1300 (stations NZ$10.50 each plus freight within NZ). Contrac baits containing the toxin bromadiolone were used, which would be equally appropriate for Niue, supplied in 8kg pails at a cost of NZ$93.50 each plus freight. Each pail contains approximately 285 baits.

**Photo: Contrac rat baits**

The smaller area of Mt Talau (7 hectares) required only 23 bait stations. Analysis of the results there showed that the bait take declined significantly over a 12-month period indicating that the rat population had declined. There were eight bait checks carried out during the year with a total of 630 baits placed within the stations (an average of 27/station) and about half of these were eaten.

The larger the poisoning grid used the more effective it will be as a trial because rat immigration from outside the grid will be reduced, though at Mt Talau even a small 7ha grid was effective. There is clearly a trade off against the resources required and indicative figures are provided in Table 9 below for two grids: 20ha and 50ha.

**Table 9: Indicative figures for trial bait station grids.**

| Size of grid (ha) | Approx. no. bait stations | Cost of stations (NZ$) | No. bait buckets per year (c.30 baits per station) | Cost of bait (NZ$) | Cost of stations & bait (NZ$) | Labour requirement |
|---|---|---|---|---|---|---|
| 20 | 110 | 1155 | 12 | 1122 | 2277 | 2-4 people 1 day/month. |
| 50 | 320 | 3360 | 42 | 3150 | 6510 | 2-4 people 2 days/month |

**Notes:** These figures exclude freight costs, time and materials (markers and tape) to set up the grid, GPS, time to put results into a database and analyse them. Labour requirements may depend on how safe it is for one person to fill some bait stations on their own.

Monitoring of the results and outcomes of the grid would be required. 5-minute bird counts (3 days at a time) repeated annually or ideally twice a year could provide evidence of any positive outcomes for birdlife. However with the small variety of birds present and doubts about the impact rats have on them (compared to storm events for example), some direct monitoring of rats using tracking tunnels or chew cards would also be advisable.

It is noted that the Rarotongan programme to protect the kakerori uses 750 bait stations and this provides an indication of what might be needed to benefit bird species at a population level in Niue. This programme could also provide figures on the effort (people and $$) required.

## 6.0 Assessment of the Feasibility and Benefits of Managing Yellow Crazy Ants

### Threat posed by yellow crazy ants

Yellow crazy ants are listed among the world's 100 worst invasive species (Lowe et al. 2004). According to the Global Invasive Species Database: '… *(they) have invaded native ecosystems and caused environmental damage from Hawaii to the Seychelles and Zanzibar. On Christmas Island in the Indian Ocean, they have formed multi-queen supercolonies. They are also decimating the red land crab (Gecarcoidea natalis) populations. Crazy ants also prey on, or interfere in, the reproduction of a variety of arthropods, reptiles, birds and mammals on the forest floor and canopy. Their ability to farm and protect sap-sucking scale insects, which damage the forest canopy on Christmas Island, is one of their more surprising attributes'* http://www.issg.org/database/welcome/

Originally from Asia, they are found in many countries in the Pacific and are or have been subject to management or research in several including Australia, Samoa, Tokelau and Kiribati.

On Nu'utele Island in Samoa there were fewer larger ant species, spiders and hermit crabs in areas where YCA's were present (Hoffmann et al. 2014). On neighbouring Nu'ulua Island where YCA's have been present for much longer and occur in vast numbers, video filming at night showed a very limited invertebrate fauna compared to Nu'utele with no crabs and only cockroaches and millipedes in any number (Author's *pers. obs*.).

Yellow crazy ants had killed an estimated 10-15 million of the red land crabs on Christmas Island in the Indian Ocean in a few years (O'Dowd et al. 2003). They kill the crabs by spraying formic acid over their eyes and mouthparts, then consuming and occupying their burrows. They could have similar impacts on coconut crabs as they have on red crabs and hermit crabs and damage this important resource if numbers build up to problematic levels.

They can impact on forest ecology by protecting scale insects as a source of honeydew, increasing the impacts of these insects on trees and encouraging the spread of sooty moulds. Similarly this can lead to increased damage to fruits and other crops in bush gardens. In the worst situations the ants become so numerous that they crawl over every surface and affect any outside activities – e.g. visiting a beach, eating a meal outside. This in turn could pose a threat to tourism.

**Exclusion of other ant species**

The reduced number and species diversity of other ants on bait cards with YCA's present has two possible explanations. Either it reflects the situation in the surrounding environment so that there are fewer ants and fewer species of ants in areas where YCA are living. Or it reflects simply that YCA defend the baits and chase other ants off the cards (or other ants avoid them) and provides no useful indication of populations in the area.

In the case of the *lotoga* the bait cards seem to reflect the situation in the area for studies in Samoa also found none of this species on baits in an area infested by YCA's whereas they were quite dominant in areas with no YCA's (Abbott 2006). The *lotoga* is a large active ant that is quite easy to see, and it also has a painful bite and can be detected this way! The observation of *lotoga* in an area can be a good indication that YCA's are not present, without baiting being required.

Pitfall trapping on the same island in Samoa did find that the abundance of some other ant species was reduced in areas infested by YCA's compared to outside these areas (Hoffmann *et al.* 2014).

**Eradication**

Eradication from Niue is not considered feasible as these ants are found at many different localities around the country.

Local eradication of small populations at specific sites may be achievable but would need to be subject to trials and careful cost-benefit analysis. It would be expensive and could have significant impacts on non-target species and only make sense if uga were likely to be under significant treat, if there was an area of high biodiversity importance threatened by YCA's or an area of high tourism value where they were impacting on visitors.

Experimental control aimed at assessing what can be achieved is discussed in the next section.

**Experimental control**

The patchy distribution of YCA's around Huvalu forest is very similar to the situation in other sites in the region, e.g. Toloa Rainforest in Tonga and Nu'utele Island in Samoa. Work on local elimination or reduction of patches of ants could thus have regional benefit.

The dynamics of YCA populations are complex. In some situations numbers have increased significantly in a few years following their arrival and then dropped back again – the classic picture of a new invasive species 'overshooting' whereby numbers grow to a point that they are exceeding the food available and they then return to a level that is sustainable. In other situations, such as Christmas Island, they seem to exist at quite low levels for many years and then rapidly become a problem. This change may be associated with ants having access to large amounts of food, particularly honeydew which they can generate by 'farming' scale insects. It can also relate to the arrival of genetic mutations among the ants (e.g. on Tokelau (Gruber et al. 2012)) and the formation of super-colonies – individual colonies joining and working together (e.g. on Christmas Island (O'Dowd et al. 2003)).

It is hard to predict what will happen in Niue. Some experts consider that the current distribution may just reflect the point of introduction of the ants, moved by people and their produce along roads and tracks to bush gardens, and not mean that they will never colonise primary forest. However a preference for more open habitats was seen in New Caledonia and this may relate to food availability (carbohydrates), temperature, and even microsite humidity (Ben Hoffman *pers. comm*.). Undertaking control now seems to be the best approach if resources can be secured, because there's a risk of them building up to very damaging, uncontrollable numbers in the future.

This control should begin as an experiment in a small number of sites, assessing the possibility of eliminating patches of ants altogether or reducing them to very low numbers.

Management or trial operations to poison YCA's by aerial or ground delivery of baits have been carried out on several sites including Christmas Island (Boland et al. 2011), Tokelau (Abbott 2006), northern Australia (Webb & Hoffmann 2013), Samoa and Hawaii. Several toxins such as fipronil (e.g 'Antoff') and hydramethylnon have been used in a variety of baits including fish meal, and insect growth regulators such as pyriproxyfen (Distance Plus) and methoprene (Engage P Ant Bait) also used. A combination of both approaches may be best. Making baits from local ingredients is advocated by some experts. Most toxins in current use do impact on crabs so consideration of the risks to uga would be required, though it may be that the habitat overlap between YCA's and uga is limited. Research on alternative ant baits and toxins is ongoing worldwide.

There are too many different baiting options to provide costs for a control programme. However the human resources required are not great and hand-laying of baits and monitoring changes in ant populations is relatively straightforward. The timing of baiting can be important as it can be most effective when colonies are not producing queens (Hoffman et al. 2014).

## Selecting sites for control

Where to carry out control is a decision that can be based on several factors. From an experimental viewpoint the inland start of the Vinivini Track where the delimiting survey was carried out is one option. Here it would be possible to assess the extent to which poisoning can reduce the numbers and distribution of YCA and/or slow their spread. We have some current information and there are roads and tracks that make access easier and clearly define the area.

If coconut crabs are recognised as 'at particular risk' from the spread of YCA's, then carrying out control in habitat favoured by them, and monitoring crab numbers,  would be another option. A recent survey assessed crab numbers across six habitat categories and showed that coastal forests held the most crabs (Table 10) (Helagi et al. 2015). The Liku Seatrack could be an experimental site in this habitat as YCA's were only found at the last station on the track by the coast. If they are only occupying quite a small area here centred on the track it might be possible to eradicate them. If their return can be prevented then a large area of coastal forest can potentially be kept free of them.

**Table 10; Catch rates of coconut crabs in different habitats (modified from Helagi et al. 2015).**

| Forest Category | Average Catch per Unit Effort |
|---|---|
| 1km Coastal Primary Forest* | 1.64 |
| 1km Coastal Secondary Forest | 1.46 |
| 1-2km Coastal Primary Forest** | 0.41 |
| 1-2km Coastal Secondary Forest | 0.3 |
| Interior Primary Forest | 0.11 |
| Interior Secondary Forest | 0.06 |

* Within 1km from coast
** Between 1 and 2km from coast

### Monitoring

Monitoring the results on YCA numbers would be relatively simple using non-toxic baits on cards as done for this survey. Monitoring non-target impacts is more time consuming and requires the establishment of pitfall traps and the involvement of an expert entomologist paid to analyse samples and identify invertebrates. Specific crab monitoring would also be relatively simple to establish using baits.

## Recommendations

- Further discuss the development of a trial bait station poisoning grid to control rats at Huvalu Forest and establish this if the resources are available and justification agreed.
- Liaise closely with other programme to control rats in Tonga, Rarotonga and Tahiti.
- Establish a programme to trial the control of yellow crazy ants with poisoned baits to achieve local elimination of colonies, or significant reductions in numbers, to slow or prevent their spread.
- Educate people, particularly farmers, to reduce the movement of yellow crazy ants by people, if a control programme is to be initiated.
- Carry out a study of feral cat diet.
- Keep developments in feral cat control and monitoring under review for new techniques that could be applied in Niue.
- Continue the current pig control programme
- Collect data on the nesting of pekapeka during a nationwide cave survey as proposed in the NBSAP.
- Continue to monitor bird populations (as identified in NBSAP Action Plan).
- Initiate awareness programme on hega and olive small-scaled skink (as identified in NBSAP Action Plan) in the hope that populations can be located, then apply experimental rat and feral cat (for skink) control here.

## Acknowledgments

I gratefully acknowledge the key role of the field team led by Huggard Tongatule who tackled the quite demanding and repetitive fieldwork with great enthusiasm and good humour. Brendon Pasisi, Director, DAFF, Dave Moverley, Invasive Species Adviser, SPREP, and Sauni Tongatule, Director, Environment provided their customary support and encouragement, and Poi Okesene helped with logistics. The following international experts kindly shared their knowledge and ideas:  Kirsti Abbott, Monica Gruber, Ben Hoffman, Cas Vanderwoude (management of yellow crazy ants), Ralph Powlesland (Niue birds and rats). As always it was a satisfying and pleasurable opportunity to work with the people caring for Niue's biodiversity.

## References

Abbott, K. 2006. Challenging the yellow crazy ant, *Anoplolepis gracilipes*, on Tokelau; development and implementation of control options for invasive ants.  Unpubl. report, Victoria University, Wellington, NZ.

BirdLife International (2016) Species factsheet: Pomarea dimidiata. Downloaded from http://www.birdlife.org on 04/02/2016.

Boland, C.R.J.; Smith, M.J.; Maple, D.; Tiernan, B,; Barr, R.; Reeves, R. & F. Napier. 2011. Heli-baiting using low concentration fipronil to control invasive yellow crazy ant supercolonies on Christmas Island, Indian Ocean. Pages 152-156 in Veitch, C.R.; Clout, M.N. $ D.R. Towns (eds.). 2011. Island invasives: eradication and management. IUCN, Gland, Switzerland.

Butler D.J. 2016. Repeat monitoring of birds and vegetation following rat control, Toloa Rainforest & Mt Talau, Tonga. Unpubl. report to Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC) and Secretariat of the Pacific Regional Environment Programme (SPREP). David Butler Associates, Nelson, NZ.

Butler, D.; Lindsay, T. & J. Hunt. 2015. Paradise Saved – the remarkable story of New Zealand's wildlife sanctuaries and how they are stemming the tide of extinction. Random House, Auckland, New Zealand. 400pp.

Cunningham, D. & P.J. Moors. 1996. Guide to the identification and collection of New Zealand rodents. 3rd Edition. Department of Conservation, Wellington.

Gruber, M.A.M.;  Burne, A.R.; Abbott, K.L.; Pierce, R.J. & P.J. Lester. 2012. Population decline but increased distribution of an invasive ant genotype on a Pacific atoll. Biological Invasions. DOI 10.1007/s10530-012-0312-z

Hoffmann, B.D.;  Auina, S.; & M.C. Stanley. 2014. Targeted research to improve invasive species management: yellow crazy ant *Anoplolepis gracilipes* in Samoa. PLos ONE 9(4): e95301. Doi:10.1371/journal.pone.0095301

Lowe, S.; Browne, M.; Boudjelas, S. & De Poorter M. 2004. *100 of the World's Worst Invasive Species: A selection from the Global Invasive Species Database.* Updated & Reprinted 2004. ISSG, Auckland, New Zealand.

O'Dowd, D.J., Green, P.T. & Lake, P.S. 2003. Invasional 'meltdown' on an oceanic island. *Ecology Letters* 6: 812-817.

Powlesland, R.G. & J.R. Hay. 1995. The status of birds, the peka and rodents on Niue Island during 1994-95. Unpubl. report, Science & Research Division, Department of Conservation, Wellington, NZ. 59pp.

Powlesland, R.G., D.J. Butler & I.M. Westbrooke. 2006. Status of birds and rodents on Niue following cyclone Heta in January 2004. Unpubl. report, Research & Development Series 234. Science & Technical Publishing, Department of Conservation, Wellington, NZ. 27pp.

Robertson, H.A,; Ian Karika. I.; Mateariki.G.; Nia, L. & E.K. Saul. 2009. Long-term management of kakerori (*Pomarea dimidiata*) in the Cook Islands. *DOC Research & Development Series* 313, Department of Conservation, Wellington, NZ.

Russell. J.C. & N.D. Holmes 2015. Tropical island conservation: Rat eradication for species recovery. *Biological Conservation* 185: 1-7.

Webb, G.A. & B.D. Hoffman. 2013. Field evaluations of the efficacy of Distance Plus on invasive ant species in northern Australia. J. Econ. Entomol. 106(4): 1545-1552.