

# RESTORATION OF ALEIPATA ISLANDS, SAMOA

## ASSESSMENT OF OPTIONS FOR CONTROL OR ERADICATION OF YELLOW CRAZY ANTS ON NUULUA ISLAND

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### 1. Introduction

The yellow crazy ant (YCA) (*Anoplolepis gracilipes*), also known as the long-legged ant, is listed as one of the 100 of the world's worst invasive species. Native to Africa or Asia, the YCA has been accidentally introduced to many parts of the world including islands in the Indian Ocean and the Pacific.



Yellow crazy ants swarming over a red crab, Christmas Island.  
(Email sent seeking permission to use photo)

In Samoa the YCA is present on parts of Upolu (including Apia, Aleipata coast, Aganoa Beach) and on Nuulua, an offshore island recognised as one of the key sites for biodiversity conservation in the country. It currently appears to be absent from the neighbouring island of Nuutele.



Aleipata District on the east coast of Upolu and its four offshore islands – Nuulua (25ha) is on the right and Nuutele (108ha) is the larger island in the centre of the picture.



Nuulua Island (25ha)

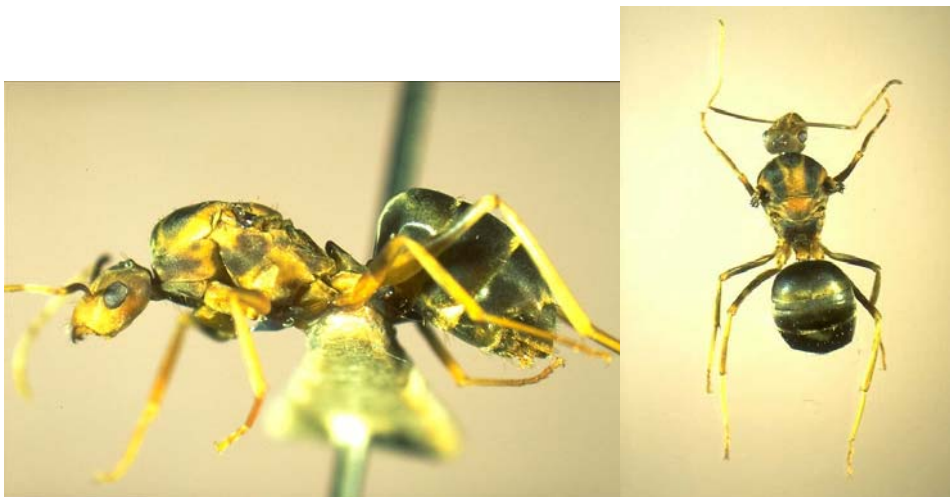
The ants are present in very large numbers on Nuulua and are a significant threat to the island's native fauna and flora – indeed they may already have caused significant changes in its invertebrate populations.

## 2. Description

Yellow crazy ant workers are around 4mm long, larger than most invasive ants, yellowish-brown in colour with noticeably long legs and antennae. The species is named for the rapid, frenzied movements shown by the workers when they are disturbed. The queen is almost 10mm long, more than twice the size of the workers, with a large black and yellow striped thorax and large black abdomen.



Worker



Queen

### **3. Ecology**

#### **3.1 Habitat & diet**

Yellow crazy ants occupy a wide variety of habitats including urban areas, agricultural land and forests. They have a broad diet characteristic of many invasive ants, and are scavengers and predators on a variety of litter and canopy invertebrates such as small isopods, myriapods, molluscs, arachnids, land crabs and insects (O'Dowd *et al.* 1999). They may occasionally feed on small reptiles and other invertebrates. In the Seychelles, they feed on invertebrates and, in culture, attack, kill, and dismember large arthropods (Haines *et al.* 1994, in O'Dowd *et al.* 1999). Like all ants, they require protein-based foods for brood production (O'Dowd *et al.* 1999). They also rely heavily on carbohydrate-rich nutrient sources such as fruit juices, plant nectar or honeydew excreted by a variety of sap-sucking insects (especially those of the genus Homoptera).

#### **3.2 Breeding**

Yellow crazy ants live in nests under leaf litter, underground (e.g. in crab burrows) or in trees. Colonies are polygynous, i.e. have multiple queens (a single nest can contain over 1000 queens and tens of thousands of workers). Workers are produced continuously throughout the year and sexual offspring may occur year-round but are generally produced seasonally (prior to the rainy season) (Baker 1976, in O'Dowd *et al.* 1999). Colony budding, i.e. queens walking on foot accompanied by workers to a new nesting site, is the main form of dispersal. Winged queens and males (known as alates) have been reported on Christmas Island but it is unclear if winged forms of the ant are able to start new colonies themselves.

The life cycle has been estimated to take 76-84 days. Eggs hatch in 18-20 days, and worker larvae develop in 16-20 days. Pupae of workers require around 20 days to develop, while those of queens develop in 30-34 days.

#### **3.3 Super-colony development**

Yellow crazy ant populations seem to exist in one of two possible states. Either there are a series of different colonies, effectively in competition with each other and the population stays within acceptable limits. Alternatively, super-colonies are present consisting of a large number of colonies of related ants which cooperate with each other, and the population increases dramatically to several thousand ants per square metre of forest causing major problems.

Yellow crazy ants arriving on a new island seem to remain in the first state for some years and then change. For example they were accidentally introduced to Christmas Island in the Indian Ocean between 1915 and 1934, but remained in relatively low numbers until 1988 when an isolated infestation of very high densities was found. Since then super-colonies developed over most of the island until an aerial poisoning programme was developed.

On Nuulua ant densities seem to have increased dramatically between the early 1990s and 2003.

## **4. Threats posed by Yellow Crazy Ants**

### **4.1 Direct impacts**

#### 4.1.1 Invertebrates

The most significant direct impacts are on the other invertebrates that form the bulk of their food. These are typically overwhelmed by spraying with formic acid from the tip of the ant's abdomen before being killed.

Infested areas contain fewer other invertebrate species. Detailed pitfall studies on Bird Island, Seychelles showed that YCA's altered the composition of the ground invertebrate fauna. Crustacea (amphipods and isopods) and Dermaptera (earwigs) which were common at other sites were almost absent from ant-infested areas (Hill *et al.*, 2003). One species of ant cricket (Orthoptera) was very abundant where the ants were present and cockroaches (Blattoidea) were also at higher densities there.

The most dramatic impact of YCA's has been on Christmas Island in the Indian Ocean where they have killed an estimated 20 million of the famous red crabs (c30% of the population) (refs?]. This decimation of the population of this keystone species has resulted in major changes in the whole ecosystem (see 4.2). They also kill robber (coconut) and other crab species.

YCA's have also been implicated in the depletion of native fauna in lowland Hawaii, the reduction in species diversity in coconut plantations in the Solomon Islands and the displacement of native ant species in India and the Seychelles. They have apparently excluded endemic spiders within a 300-600 m altitudinal zone in Hawaii.

#### 4.1.2 Vertebrates

There are two examples where YCA's may have had an impact of reptiles. In parts of the Seychelles they are thought to have greatly depleted populations of the native skink *Mabuya sechellensis* which were ten times more numerous outside ant-infested areas. On Christmas Island the giant gecko (*Cryptodactylus sadleiri*) is found in lower numbers in areas of ant supercolonies

YCA's can be a threat to birds, either through disrupting nesting or killing young. On Bird Island, Seychelles they caused sooty terns to abandon 1.5ha of their colony. On Christmas Island (CI) they have apparently reduced numbers of doves and thrushes either directly or through inducing changes in vegetation. The CI Emerald Dove is of particular concern. Direct attacks have been seen on injured doves, though it is unsure whether ant attack caused the injury and there have been unconfirmed reports of killing nestlings. Changing forest structure with a thicker understorey will have made foraging on the ground more difficult and the doves also face competition for food there and aggressive attacks from ants.

Seabirds for which Nuulua is very significant may also be at risk, with adults potentially harassed on nests whether they are on the ground or up trees, and predation of eggs and chicks possible. Hole-nesting birds may find their nest-sites taken over by ants.

Finally YCA's may also be a threat to nestling turtles.

#### **4.2 Indirect impacts**

YCA's may lead to secondary impacts through increasing the numbers of scale insects or coccids. These insects feed on the sap of plants and produce excess as a sugar-rich honeydew which the ants feed on. Ants also eat the predators and parasites of the sap-sucking insects enabling them to build up huge populations. These in turn increase the stress on trees through their feeding causing foliage loss and even death. On Bird Island, Seychelles dead standing trees were only recorded in areas of YCA infestation and canopy cover was reduced in these areas to 73% compared to 95% and 97% elsewhere (Hill *et al.* 2002). The large quantities of honeydew provide ideal conditions for the growth of sooty mould fungi which can reduce plant photosynthesis and also contribute to dieback. Reduce tree foliage increases the light reaching the forest floor and can provide ideal conditions for weeds.

On Christmas Island the YCA's had a dramatic impact by removing millions of red crabs which were a major seed, seedling and litter consumer. This led to changes in forest structure, producing masses of seedlings where previously the forest floor had been fairly open, and in species composition. The combined direct and indirect impacts on the native biodiversity of the island have been described as 'invasional meltdown' (O'Dowd *et al.*, 2003) causing catastrophic change to the ecosystem.

#### **4.3 Impacts on people and livelihoods**

YCA's are regarded as a nuisance in homes where they crawl over people and food and the formic acid they spray can cause skin burns and irritate eyes. There are records in the Seychelles of ants killing newly-hatched chickens and newly born domestic animals such as pigs, dogs, cats and rabbits, and driving away older animals. Increasing the amounts of sooty mould, through protection of coccids on plants, has affected various crops in the Seychelles, including cinnamon and citrus, probably reducing yields. YCA's have been associated with the spread of *Aphis craccivora* on *Gliricidia sepium* in Kerala, India, mealy bugs causing wilt disease on pineapple in Taiwan and powdery mildew disease on mulberry in Karnataka, India .

### **5. The situation on Nuulua Island**

During the 2003 expedition to Nuulua it was found that the forest floor was covered in fast moving ants later identified as Yellow Crazy Ants, and they were also seen in trails on all tree trunks. Infra-red video showed that ants were also active in similarly large numbers at night. Those who made the earlier visits to the island had not noticed this phenomenon and it is assumed to have been a recent development.

The previous analysis suggests that the following possible changes might result from the invasion of Nuulua by YCA's:

- Changes in the invertebrate fauna particularly reduced numbers of crustacean, including crabs and increases in ant crickets and cockroaches
- Increases in sap-sucking insects and sooty moulds reducing tree health and causing tree death
- Changes in forest structure and composition due to losses of land crabs (though nothing like as dramatic as on Christmas Island where endemic red land crabs are a keystone species)
- Declines in populations of lizards
- Declines in some bird populations, particularly ground birds, resulting from nest losses or competition for food
- Reduced nesting success of some seabirds
- Losses of hatchling turtles
- Reduced numbers of rats – impacts on small mammals have not been demonstrated but seem possible

Detailed studies have not been undertaken but some changes are evident.

The video showed numerous cockroaches and almost no crabs active at night, whereas the opposite was found on neighbouring Nuutele where YCA's have not yet been detected. Friendly Ground Doves, a ground bird similar to the Christmas Island Emerald Dove, were not sighted on the most recent expeditions to the island though an occasional bird was seen in the past.

Surveys planned for July will provide more detailed information on invertebrates and assess scale activity and any impacts on vegetation.

## **6. The situation on Nuutele Island**

Yellow crazy ants have not been detected on neighbouring Nuutele Island (108ha) despite ants being sampled on at least three occasions. Currently it is assumed that they are absent or present in very low numbers and no management is proposed there. However all teams visiting Nuutele on rat and ground dove work will be encouraged to look out for crazy ants.

## **7. Management options for Nuulua Island**

### **7.1 Do Nothing**

Taking this option is likely to result in irreversible damage to the ecosystem of Nuulua, including changes in forest structure and composition and massive population reductions or extinctions of many native species including birds for which the island is the key nesting habitat in Samoa. It would render the proposal to eradicate Pacific Rats from the island a waste of time and resources and the goal of restoring it as a key site for conserving native species unachievable.

### **7.2 Eradication of YCA's or their control to reduced levels through poison baiting**

Poison baiting has proven successful in significantly reducing the numbers of ants at a number of sites. Whether **eradication** can be achieved is doubtful given that any queen that survived could establish a new colony. It would also be operationally impossible to locate a small number of colonies if they survived the initial operation to kill them subsequently in a ‘mop up’. **Control** to levels low enough for the impacts on native biodiversity to be significantly reduced or almost eliminated should be feasible.

The Federal Government has spent more than \$1.5 million on controlling yellow crazy ant on Christmas Island. The control programme began with large-scale ground baiting during the 2000 dry season, and while it was effective in areas treated some parts of the island were too rugged to tackle. Following this, in 2002, a highly successful aerial baiting program was conducted. It involved the distribution of almost 12 tonnes of bait over 2 400 hectares via helicopter. Yellow crazy ants are still present in low numbers on Christmas Island and continued surveillance is needed to detect the formation of any new supercolonies. It is hoped that new infestations will be small enough to be controlled by ground baiting (Parks Australia 2005).

## 8. Poison baiting techniques

A baiting technique has been developed using protein bait pellets made of commercial fishmeal laced with insecticide and spread in the vicinity of the nests. The foraging ants collect the pellets and carry them back to the nest where the bait is shared around and eventually given to the queens. As the queens are the only ants able to reproduce, the death of the queen ensures that the colony is destroyed.

### 8.1 Choice of toxin

A comprehensive review of baits used for ant eradication and control was carried out recently (Stanley, 2004). It identified fipronil in two protein-based bait matrices (Presto® and Xstinguish®) and **hydramethylnon** (Amdro®) as effective at controlling several species. Two insect growth regulator baits developed to control red imported fire ants (RIFA) (*Solenopsis invicta*), Engage® (**methoprene**) and Distance® (**pyriproxyfen**) were the most effective of this type. **Indoxacarb** was listed as a new ‘reduced risk’ toxin that has also proved effective against RIFA in the bait Advion® (0.045% indoxacarb).

The first successful poisoning operations against YCA’s, in the Seychelles in the 1970s, used the toxin **aldrin** (no longer acceptable due to its environmental persistence) in a solid protein base (with sugar, salt, yeast (marmite)).

**Fipronil** mixed with a fish protein base (i.e. Presto® - developed by Bayer Crop Science and Animal Control Technologies) was chosen to control YCA’s on Christmas Island following a two-year search (1999-2000) by Australian National Park staff looking for a slow-acting bait with a low level of toxicity. Fipronil is an effective insecticide (acting as a neurological inhibitor) that may effective at doses of less than 0.5 grams of active toxin per hectare (a level that is not harmful to reptiles, birds or mammals). It does not dissolve in water (Parks Australia 2005). The

concentration chosen had to be low enough so that foragers will live long enough to return enough bait to the colony and disperse it among other workers, larvae and the queen. Both Presto 01® (0.01% fipronil) and Presto 001® (0.001% fipronil) proved effective though the latter took longer to achieve a ‘knock-down’ (Green *et al.*, 2004). Applying the precautionary principle to minimise non-target impacts the lower concentration was recommended for future work.

An ongoing programme to test a variety of the newer baits has been carried out on Tokelau, a country of three atolls to the north of Samoa, since 2003? [or 2004] (K. Abbott, pers. comm.). Presto 001® and Distance® were tested in the past two years and currently (2006) **indoxacarb** [is it as Advion®?] is being trialled for the first time on YCA’s (*funded in part through support to CEPF from the Australian Government’s Regional Natural Heritage Programme*) with results due to be known by the end of June. Advion has previously been successfully tested on red imported fire ants in Texas (Barr 2002)

Baiting with Presto 001 and spraying with Termidor (a pesticide containing fipronil) are being used to treat infestations of YCA in Queensland, significantly reducing the size and severity of infestations (Vanderwoude & Abbott, 2006).

#### Characteristics of indoxacarb and fipronil

<b>Indoxacarb</b>	<b>Fipronil</b>
Used on vegetables and other crops around the world as an insecticide	
Fast-acting - foraging suppressed within 1 or 2 days ( <i>S. invicta</i> )	
Eliminates most colonies with single broadcast operation ( <i>S. invicta</i> )	
Ant’s digestion produces an even more toxic product	
Non-target risk reduced – digestion of other animals works differently and does not produce the same more toxic product	
Only moderate toxicity to birds	
Moderate to very highly toxic to fish and marine invertebrates	Highly toxic to fish and marine invertebrates
Relatively immobile in soil	
Non-target risk values very low when compared to those of alternative chemicals (EPA Fact Sheet)	
Does not cause mutagenic, carcinogenic, developmental or reproductive effects (EPA)	
No fish bioaccumulation (EPA)	
Minimal environmental residues of this chemical in water resources are expected (EPA)	

## 8.2 Choice of delivery method

Both ground and aerial delivery of baits have proved effective and are options that can be considered on Nuulua as follows:

### Option 1: Aerial baiting of whole island

This would be the most cost-effective option if a helicopter is available – e.g. if one has already been placed at Aleipata for rat operation. It is:

- not dependent on sea conditions allowing regular access to the island
- going to allow all parts of the island to be reached by bait including steep parts of cliffs
- going to leave some baits up in trees which may facilitate the killing of any ant nests there
- the most likely option to achieve eradication if any will

However one negative is that some baits will go into the sea where impacts on fish or marine invertebrates are possible (see non-target impacts below). Also a considerable effort was needed on Christmas Island to dry Presto baits before they would flow through the spreader bucket. Whether this is still an issue might depend on which bait was used.

### Option 2: Ground baiting of whole island

This would be impossible to achieve as some areas of the cliffs can be considered inaccessible. Leaving these areas untreated would mean that eradication was impossible and the benefits of control would be shorter-lived as ants from the cliffs would recolonise the rest of the island in time.

### Option 3: Ground baiting of accessible parts of island and aerial baiting of cliffs.

To prevent the risk of non-target impacts on the marine environment the reverse of this would be desirable but clearly impossible. Ground-baiting of parts of the island could make it easier to protect crabs from baits, if this is considered necessary (see non-target impacts below).

## 8.3 Timing

Further discussion and the July field surveys are needed to determine what is the ideal time of year to conduct the poisoning? Possible variables are ant behaviour (i.e. particularly worker numbers and preferred foods), weathering of baits and the ability of teams to reach the island (i.e. sea conditions) and /or a helicopter to operate.

September was identified as the ideal time on Christmas Island (Green *et al.*, 2004) for the following reasons:

- ants are more active at this time compared to the wet months of the year
- ants are likely to be seeking protein in the lead up to their annual breeding cycle<sup>1</sup>

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<sup>1</sup> Protein is needed for queen maintenance and brood production (Vanderwoude & Abbott 2006).

- activity of red and robber crabs is relatively low reducing probability of non-target impacts
- low probability of rain which would hamper helicopter operations and suppress ant activity
- wind is relatively constant in speed and direction (significant for helicopter use)
- tree canopy is relatively thin after the effects of the preceding dry months allowing more bait to reach ground.

Many of these factors would be equally relevant for Nuulua (though no red crabs are present). How wide a window they represent needs to be worked out but it is likely to be several months.

A further question is what should the order of baiting be if both rats and ants are to be tackled on Nuulua? Will rats feed on ant baits and vice versa? Will there be sufficient competition or disturbance to make this an issue?

It appears that a single baiting may be sufficient for ants whereas two are planned for rats some days apart. One baiting sufficed for YCA on Christmas Island with ant activity effectively nil 12-15 days after treatment (80% reduction after 2 days using higher concentration).

## **9. Possible non-target impacts of poison baiting**

### **9.1 Using Fipronil**

Detailed work has been undertaken on the possible non-target impacts of **fipronil**-based baits on Christmas Island (Stork *et al.*, 2003; Green *et al.*, 2004). This suggests that the following might be at risk if this approach was adopted on Nuulua:

- land crabs, including coconut (robber) crabs

It also indicated no adverse impacts on:

- nesting seabirds – neither from baits or helicopter activity
- a range of landbird species<sup>2</sup> (island thrush, Christmas Island white-eye, emerald dove – a similar bird to the friendly ground dove)
- litter invertebrates (largely because YCA's dominate the baits)
- reptiles – there were no changes detected in the abundance of the nocturnal Christmas Island gecko detected five months after baiting

It provided no information on:

- impacts on marine environment (baits not dropped along coast?)

### **9.2 Using indoxacarb**

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<sup>2</sup> Number of the Christmas Island imperial pigeon did appear to have declined between pre-baiting and post-baiting surveys. Being a fruit eater there was no obvious mechanism for it to have obtained poison and seasonal changes in detectability were the more likely explanation.

This is currently being studied by the Victoria University research team on Tokelau and some results should be available shortly. Reduced non-target impacts is one reason for trialling indoxacarb as an alternative to fipronil.

### **9.3 Managing non-target impacts**

#### 9.3.1 Land crabs

Whether there is any seasonality in the risk of coconut (robber) and other crabs taking baits on Nuulua is uncertain. However an approach used on Christmas Island could be adopted if considered necessary. There robber crab mortality was reduced from a predicted 15% (from trials) to 5.4% by providing poultry pellets. Concentrated drops (80% of pellets within c. 8m circle) were made at specific sites used by robber crabs 1-2 days before areas were treated with ant bait.

July surveys should provide an indication of robber crab numbers on Nuulua and their distribution and whether any protection measures are needed. It could be that the ants have almost caused their extinction on Nuulua and reintroducing animals from Nuutele may be a more cost-effective option than trying to protect a few remaining ones from poisoning.

#### 9.3.2 Other species

As indicated earlier, work on Christmas Island suggested that there were no adverse impacts on birds or reptiles from the use of fipronil. If indoxacarb is used it is considered even less toxic to these species so no action seems required.

However both fipronil and indoxacarb are toxic to marine invertebrates and fish. Any poison falling into the sea would be rapidly highly diluted given the wave action around the island. No specific measures are obvious to address what are likely to be negligible adverse impacts on the marine environment. However monitoring is being discussed to provide information for future such operations in the region. {Some data may be available from Tokelau research on this}.

## **10. Monitoring**

[to come]

## **11. Recovery projections for Yellow Crazy Ants on Nuulua**

On Mahe, Seychelles toxic baits were used to kill over 90% of a YCA population in a few days. Where a 2-ha area had been treated, the population recovered to about half of its previous level within 85 days (c 3 months), whereas a 50ha area required 300 days (c10 months) to do the same (Haines & Haines 1979).

On Christmas Island YCA's were found to be widespread at extremely low (non-supercolony) densities across the island about 1 year after aerial poisoning that reduced worker activity by over 99%. (Green

One would predict that an efficient operation would reduce YCA's to very low levels on Nuulua and their recovery to current levels would take several years if not tens of years. One interesting question is whether it would be feasible and worthwhile to treat scale insects, e.g. by spraying, to reduce the honeydew food source and thus slow the process of ant population recovery.

## **12. Preventing Yellow Crazy Ants re-colonising/colonising Nuulua and Nuutele**

Yellow crazy ants appear to have colonised new islands in a variety of materials: e.g. soil, agricultural produce, timber, and packaging. Thus very detailed protocols of treatment and inspection will need to be put in place on any materials going to Nuulua. There should be minimal requirements for materials to go to the island as the current restoration plan (in draft) contains measures banning the planting of crops, construction of buildings, etc.

So the more likely route for YCA's to reach Nuulua are in the equipment and food taken to the islands by visitors – largely parties under conservation management on the island at this time. As it only needs one queen to arrive to establish a new colony [check this and complete the section] – however it does not matter how many workers arrive if no queens do [check].

[add shipwreck - fishing boats/canoes seeking shelter]

[add – different risks for Nuutele]

## **13. Recommendations**

1. The YCA population on Nuulua needs urgent control to prevent potentially irreversible damage to the island's native animals and plants
2. Poison baiting should be undertaken as a technique that has been proven elsewhere in similar conditions
3. Aerial poisoning may be the preferred baiting method as it is likely to prove more cost-effective than ground-baiting
4. The need for measures to protect coconut (robber) crabs has to be assessed.
5. Detailed mechanisms need to be put in place to prevent YCA's reaching the islands in the future

[Note: This draft assessment will be completed once the results of current trials on Tokelau are known].

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[to be completed]

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## **Annex 1: Questions:**

Any need for parallel work on sap-sucking insects to reduce potential recovery rate of ant population? Re-introductions of invertebrates?

For Kirsti – was bait damp?

### **Questions for surveys**

How are ants distributed on Nuulua and do they prefer particular habitats? (They appear to be throughout the island but densities may reduce slightly at higher altitudes towards the top ridge).

What evidence is there of impact on vegetation – increased scale – sooty mould – dieback – canopy thinning - tree death? What plants are 'scale insect prone'?

Reproductive status of ant colonies

Monitoring:

Intact crab burrows vs ant-occupied crab burrows (proving occupancy?easy).

Are significant nos. of crabs (incl. coconut crab - u'u) present – would baiting with poultry pellets be worthwhile?

Sampling- paint brush dipped in alcohol – may collect 10-20 ants from different areas for subsequent DNA testing to identify forms present?