Managing the impacts of the little fire ant (*Wasmannia auropunctata*) in French Polynesia

A report prepared by the Secretariat of the Pacific Regional Environment Programme
for the Government of French Polynesia and Fonds Pacifique

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Managing the impacts of the Little Fire Ant (*Wasmannia auropunctata)* in French Polynesia

Secretariat of the Pacific Regional Environment Programme
Apia, SAMOA

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Acknowledgements

The concept for this project was developed following a visit and a request for assistance from Bran Quinquis, Deputy Mayor of Mahina Commune, French Polynesia, to SPREP in 2012. We thank the Mayor of Mahina Commune, Mr. Patrice Jamet and Mahina counsellors for their support for the project and the hospitality shown during our visits. We met with many organisations in French Polynesia over the course of this project and they provided valuable feedback that assisted greatly with development of project outcomes. We thank the Tahiti Tourism Authority, Mo'orea Commune, CRIOBE, Te Puti Atahia, Association PGEM Mo'orea, Delegation a la Recherche, Direction des Resources Marines, Institut Louis Malarde, Fenua Animalia, Association Tamarii point des pecheurs, SOP-Manu, Directeur de l'environnement and the Service du développement rural. We also acknowledge the contributions of many partners and individuals, including Alan Tye, Gilles Lorphelin, Engel Raygadas, Gabriel Sao Chan Cheong, Marie Fourdrigniez, Eliane Garganta, Rudolf Putoa, Jean-Yves Meyer, Matai Depierre, Christophe Brocherieux, Jerry Biret, Brenda Sherley and G. Robin South. The people of Mahina are greatly acknowledged for their support and hospitality. Funding for this work was generously provided by Fonds. Additional funding support was provided by SPREP and the Mahina Commune.

Foreword

There is a saying in our region:

'*If you want to go fast, go alone. If you want to go far, go together.*'

This is particularly relevant to the major challenges of Pacific invasive species and waste management where we must work together across disciplines and across boundaries to ensure effective and lasting impacts.

This was also emphasised at the 2013 Pacific Island Forum Leaders Meeting in the Marshall Islands where Pacific Leaders agreed that:

'*Integrated action through effective partnerships was required to actively address the escalating threat of invasive species on Pacific economies and environments, including efforts to enhance climate change adaptation, ecosystem resilience, food security, biological diversity and the development of sustainable economies*.'

This project represents cooperation and partnerships in action, and at all levels, from the invasive species-waste management inter-programme approach at SPREP, to working with Territorial administrations and right down to the "grass roots" level to implement solutions within the Mahina Commune of Tahiti, and with private waste managmenet businesses and through the newly developed Invasive Species Network, spread across the many archipelagos of French Polynesia.

This is a microcosm of what our Pacific Leaders are requesting and a great example of what we as a region need to do more of if we are to be successful in dealing with invasive species and waste management issues.

It is hoped that the experience from this project will not only assist with improvements in waste management practices and in the management of the Little Fire Ant and other invasive species in French Polynesia, but that the lessons learned will contribute to success in managing waste and invasive species across the region, whilst also strengthening SPREP support for the French Territories.

David Sheppard
Director General
Secretariat of the Pacific Regional Environment Programme

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Executive Summary

The little fire ant, *Wasmannia auropunctata*, is a small ant native to Central and South America which has been introduced into seven Pacific Island groups. It is considered by invasive experts to be the greatest ant species threat within the Pacific Region. Although its official discovery in Tahiti was in 2004, it is likely that the little fire ant has been present in Tahiti for much longer. The centre of contamination in Tahiti is the northern Mahina Commune. Initial treatment and monitoring initiatives to combat the ant invasion were carried out between 2005 and 2009, but were discontinued in 2010.

The little fire ant prefers the warm, moist and shaded habitats found in rainforests. There is often more than one queen per colony and although many nests are established, they are all interconnected. When the nests are disturbed, little fire ants aggressively defend their territory or resources. Little fire ants can also infest houses, forage through homes and sting people, children and domestic animals. The sting affects people to varying degrees from a painful rash to large raised welts. Stung domestic animals often suffer from keratopathy or clouded corneas, leading to blindness.

Little fire ants are known to infest green waste as well as oversized waste left out for collection. To counter human assisted transportation of little fire ants, the movement of green and oversize waste from the Mahina Commune to other areas of Tahiti was prohibited in 2006. However, this ban has hindered effective waste management in the Mahina Commune, and resulted in adverse environmental impacts from the continued use of an unregulated dumpsite used to temporarily dispose green waste and oversize waste. As a consequence, the impact of little fire ants to the Mahina Commune, Tahiti, has been more severe than other French Polynesian municipalities.

Mahina Commune approached the Secretariat of the Pacific Regional Environment Programme (SPREP) in 2012, seeking assistance for management of little fire ants and domestic waste. Funding assistance from Fonds Pacifique was secured in 2013 to assist with identifying options for Mahina's waste management issues, development of best practice for managing little fire ants including biosecurity measures, and for building capacity of locals and review of legislative options to better control the spread of the ant.

A number of conclusions were reached by the study. These included:

1. Green waste from the Mahina Commune could be composted under controlled conditions at a local site to minimise or eliminate any accidental ant transportation. Composting green wastes under controlled conditions elevates internal compost temperatures above 60° C for a sufficiently long duration to kill any insect pests (including *Wasmannia*) in the composting vegetation.
2. Strict adherence to routine quality assurance measures at the composting site including ant baiting and monitoring, compost pile temperature logging, adherence to minimum compost row separation, use of soil pesticide barriers, runoff monitoring and regular sterilization of all machinery and tools involved in composting operations would ensure that the ant was not accidentally transported in final compost products.
3. Collected metallic oversize waste to be exported overseas for recycling also present a potential source of ant contamination and transport.
4. Oversized waste collected from elsewhere in Tahiti are currently compacted and then fumigated with methyl bromide to kill any pest species (including the little fire ant) prior to export. Arrangements to also treat oversized waste collected from Mahina with the fumigant should be investigated.
5. In parallel, controlled trials should be undertaken to assess the efficacy of heat sterilization achieved through long-term sunlight exposure on metal shipping containers and their contents as an alternative to continued use of methyl bromide fumigation of compacted, oversized waste.
6. All compost produced in Tahiti is also currently fumigated with methyl bromide prior to sale. The necessity for this should be reviewed, and a public education campaign developed to explain any changes to ant control measures and to help market the Mahina compost product.
7. An assessment of any legislative changes required for improved green waste and oversized waste management in Tahiti should also be completed, and funding sought for the remediation of the Mahina unauthorised dumpsite following its closure.
8. Preventing the spread of the LFA from the existing two infested islands (Tahiti and Moorea) to the rest of the 130 islands of French Polynesia is a high priority.
9. Inter-island biosecurity measures must be strengthened to allow for thorough inspections, treatment and control of goods being shipped from Tahiti and Moorea outward.
10. Developing early detection and emergency response plans that are supported by competent and well-trained personnel is a must.

11. Engaging the wider public in a LFA control and eradication campaign will provide extra support and human resources for managing the LFA and the waste challenge. Eradication efforts should focus on eliminating small (<1 hectare) infestations, whereas containment efforts to focus on larger areas (>5 hectare).

12. Strenghtehning the legisltative authority and collaboration amongst the three jurisdictional bodies (State, French Polynesia Government and Communes), especially in the areas of controls (e.g. port of entry) and joint-investigation with police are means of improving biosecurity measures. The engagement and participation of the wider-public will ultimately decide the success or otherwise of these measures.

Chapter 1: Little fire ants in French Polynesia: Distribution, impacts and estimated population growth

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Summary

This report is the result of a scoping trip to the Island of Tahiti in French Polynesia by a team from the Secretariat of the Pacific Regional Environment Program (SPREP). The purpose of this trip was to study the recent invasion by the little fire ant (*Wasmannia auropunctata*), assist with recommendations for mitigating the impacts of the species, develop waste management procedures that minimize further spread, and make suggestions for biosecurity planning.

This report contains an assessment of the spatial distribution of little fire ants, a review of the history of introduction and spread of little fire ants and details of the current situation in the municipality of Mahina. Data presented in this report have come from a variety of sources, but primarily from detailed information furnished by Service du Developpement Rural, Direction de l'Environnement, an audit report on the response program written by Bossin and Padovani (2010), personal observations and prior knowledge of this species and control methods.

Tahiti has a near-ideal climate for the successful establishment and spread of little fire ants. This species poses a serious threat to the economy, ecological health and social well-being of Tahiti and its inhabitants. In its invasive form, little fire ants form dense three-dimensional super colonies that cover the ground, vegetation and tree canopies. The arboreal ants often fall from vegetation onto people and animals below, stinging their victims and causing blindness in domestic animals. In natural ecosystems, they prey on, or drive out native fauna, leaving an ecosystem depleted of much of its pre-existing animal life. The mutualisms formed between little fire ants and Homoptera cause crop losses in agriculture and a decline in plant health for native ecosystems.

Ten of the 13 municipal jurisdictions that encompass the administrative sub-division of the Windward Islands are infested to varying degrees with little fire ants. The most recent island-wide survey, conducted in 2010 found 79 infested sites covering 782.7 hectares. This is despite a concerted control program conducted between 2006 and 2010. Simple linear regression suggests that by 2013, this will increase to 120 sites covering 1220 hectares. Of the infested communes, Mahina (9% of land area) and Arue (4% of land area) were the most heavily infested.

The commune of Mahina covers 5,160 hectares and supports a population of over 14,000 individuals. Over 60% of this jurisdiction was infested with little fire ants. However, the potential for future spread is linked more closely to the number of small, developing infestations rather than gross infested area. Therefore the source populations for wider dispersal are likely to be located not just in Mahina but the communes of Arue, Punaauia, Hitiaa, Papeete and Faaa.

There are many options for future mitigation strategies for this species in Tahiti, and while beyond the scope of this report consideration to the following priority areas may provide the best returns on investment:

- Prevention of spread to neighboring islands;
- Emergency response planning and training;
- Public outreach and awareness;
- Early detection and response for high-value sites; and
- Progressively reducing small outlying populations of little fire ants.

Introduction

Importance and impacts of invasive species

Non-native plant and animal species are often introduced to new areas by human intervention. Many of these enhance the quality of life (for example, the introduction of food plants or animal stock for farming). Some are visually appealing and are introduced for aesthetic reasons. Yet others are accidentally introduced through human commerce. In most cases, these newly introduced species are not especially damaging and cause no noticeable impacts.

Occasionally, newly introduced species, released from the forces that regulate them in their home environment, multiply rapidly and displace or predate on native species that occupy the same ecological niches. They can simplify biological diversity, degrade and alter ecosystem functioning, cause economic losses, aesthetic harm and decrease human quality of life. These undesirable plants and animals are often referred to as "invasive".

A small number of ant species are considered invasive. Of the 15,000 or so species known to science (Holldobler and Wilson 1990), only a few have the ability to travel easily with human commerce (hitching rides with cargo, ships and aircraft), and once established, reproduce rapidly at their new location, causing a variety of impacts. The Pacific region is especially prone to colonization by invasive ant species (McGlynn 1999). The two most damaging of these are the red imported fire ant (*Solenopsis invicta*) and the little fire ant (*Wasmannia auropunctata*). The red imported fire ant prefers sunny open habitats, whereas the little fire ant is a rainforest species that prefers warm, moist and shady habitats. Although the red imported fire ant has not been recorded within the Pacific region, the little fire ant is present on a number of Pacific islands and spreading rapidly (Wetterer and Porter 2003).

The impact of an invasive ant on island ecosystems can be severe. For example, when the yellow crazy ant (*Anoplolepis gracilipes*) invaded Christmas Island, it preyed on a unique endemic land crab (*Gecarcoidea natalis*) causing massive population declines of this species (O'Dowd *et al.* 1999). Additionally, yellow crazy ants tended scale insects, a plant pest. The combination of removing the dominant detrivore (land crabs) and increasing populations of scale insects caused an ecological "meltdown" (O'Dowd *et al*. 2003) through increased light, litter and seeds on the forest floor, and the removal of the dominant seed consumer. This resulted directly in an explosion of understory plants and the death or decline of the forest canopy.

Worldwide distribution of *Wasmannia auropunctata*

The little fire ant is native to South America and is a common species throughout the lowland regions east of the Andes. Its distribution appears to be limited in its native range by other ant species. However, even there, it can become dominant in disturbed habitats (Wetterer and Porter 2003). The first known record of this species outside its native range was in Gabon (Santschi 1914, cited in Wetterer and Porter 2003). Since then, the little fire ants have been recorded in Florida (Smith 1929), Galapagos (Lubin 1984), New Caledonia (Fabres and Brown jnr 1978), Solomon Islands (Fasi *et al*. 2012), Australia, Hawai`i (Conant and Hirayama 2000), Papua New Guinea, Israel (Vonshak *et al*. 2010), Wallis and Futuna and Vanuatu (Wetterer and Porter 2003). Most recently, this species has been recorded in Guam (www2) and the island of Tahiti in French Polynesia (Theron 2005) (Figure 1).

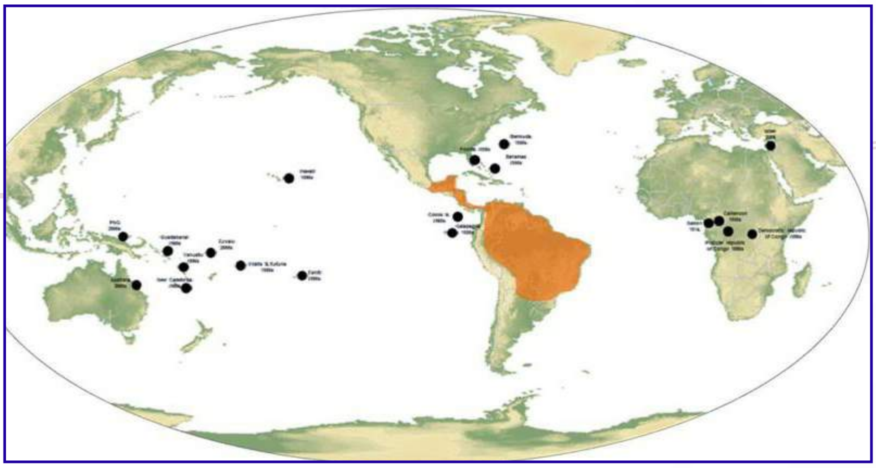

Figure 1. Worldwide distribution of *Wasmannia auropunctata*. Orange shading represents natural range, black circles represent locations where it has become established.

Little fire ant biology and ecology

Wasmannia auropunctata (Hymenoptera: Formicidae) belong to the sub-family Myrmicinae – considered to be a recently evolved sub-family with a generalized ecology (Andersen 1995). This sub-family is characterized by the possession of a distinct post-petiole and a simple gaster. All species have a sting. As their common name suggests, little fire ants are small, approximately 1 mm in length. They are a true forest species (Armbreght 2003) and prefer warm, moist and shady environments. Foraging ants avoid sunlight and dry environments. Colonies can be found both in the ground layer, in vegetation and the canopies of trees. Little fire ants do not build elaborate nests; rather they utilize any available niche such as leaf litter, under rocks or stones, cracks and crevices in trees, and hollows in decaying organic material. Colonies will readily relocate when their current nest location becomes unsuitable or a better location becomes available.

Reproduction

Little fire ants have an unusual reproductive trait. Normally, when queens reproduce, offspring share both paternal and maternal DNA. However, for little fire ants, this is not always the case. Daughters do not possess any paternal genetic material and males do not possess any maternal genetic material. Arguably, the males and females are two genetically distinct species. Some genetic mixing does occur, however for invasive populations, clonal reproduction is the norm. A detailed explanation of this very unusual form of reproduction is beyond the scope of this report but further information can be found in Fournier *et al* 2005, Foucaud *et al*. 2007, and Foucaud *et al*. 2009.

Clonality in this species has allowed geneticists to analyse the likely sources and pathways of invasive populations worldwide (Foucaud *et al*. 2010). In the Pacific region, five separate clonal lines have been identified, suggesting there were five separate introductions to the region (Figure 2). Different populations with the same clonal lines are very likely to be linked and share common introduction pathways. The clonal forms found in Tahiti are identical to those found in New Caledonia, Gabon, and Guadeloupe, and distinctly different from other populations in the Pacific region.

Density

In locations where this species has been introduced, little fire ants can achieve extraordinary population densities. In tropical orchards of Hawai`i, populations average 20,000 individuals per square meter (Souza *et al*. 2008). Queen density is also extremely high (Ulloa-Chacon and Cherix 1990) and estimates range between 36 and 77 per square meter. These extraordinary population densities are one of the factors that confound efforts to control this species.

Invasive traits

In common with other invasive ant species (Passera 1994), little fire ants exhibit several traits that contribute to their potential for invasiveness:

- Polygeny (more than one queen per colony);
- Polydomy and unicoloniality (multiple nest sites that are inter-connected);
- High inter-specific aggression (aggressive defense of territory and resources against competing species);
- Relocation via human commerce (an ability to travel to new locations attached to cargo and people); and

Formation of mutualistic relationships (protecting other insects in return for food).

Polygyny

Typically, an ant colony consists of a single queen attended by many worker ants. The queen is the only reproductive ant and the workers are her daughters - sterile females. At times through the year, new queens are produced along with males. These fly from the nest at pre-determined times, mate in flight, and the newly mated queens land to form new colonies. Workers do not tolerate more than one queen per colony. Should two or more queens be present, the worker ants will assassinate the weaker queens.

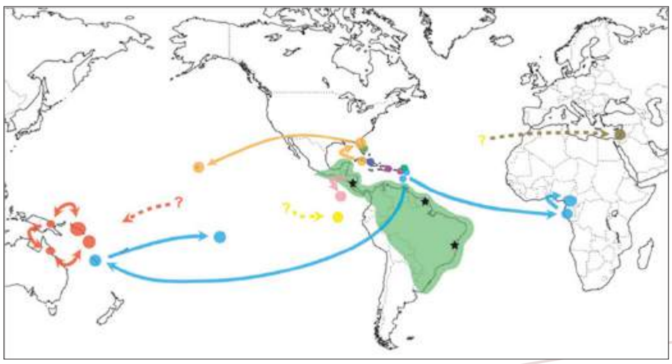

Figure 2. Clonal lines of *Wasmannia auropunctata* worldwide. Colours represent common clonal lines and presumed introduction pathways.

However, nests of invasive ants (including little fire ants) can contain many queens, and workers do not appear to distinguish between them or attempt to assassinate surplus queens. This feature gives colonies two competitive advantages. Firstly, the founding phase of a new colony carries a high risk of failure. A newly mated queen needs to lay an initial clutch of eggs, care for them until the larvae reach adulthood, before focusing exclusively on egg-laying. New queens often suffer from predation or fail to raise sufficient workers to form a colony. For little fire ants and many other invasive ant species, newly mated queens simply re-enter the parental colony, or move a short distance away with existing workers to found a new colony. The probability of successful colony founding is thus much greater. As a result, they no longer need to take part in nuptial flights and mate within the nest.

The second advantage of polygyny is that the task of egg laying is now shared between a number of queens. In single queen colonies, the death of the queen signals the end of the colony. Without new workers, the colony will decline and die. However, in multiple queen colonies, the death of one or more queens has no lasting effect on egg production. Remaining queens simply increase their rate of egg laying to compensate. This feature makes the control of this species especially difficult. Many control methods focus on killing the queen for success. When many queens are present, this task becomes much more difficult.

Polydomy and unicoloniality

Ant colonies, even from the same species, are highly competitive and expend great resources to defend their territory and resources. Large amounts of energy may be expended in this activity. The importance of this battle for survival and territory should not be underestimated. Almost all invasive ants share the traits of polydomy and unicoloniality which dramatically reduces the cost of survival.

Individual little fire ant colonies do not compete with each other. They work cooperatively, share food, workers, brood and queens. In this way they form a network of connected colonies that together exclude all other ant species. Territorial defence is only needed at the outer edges rather than around each individual colony. This network of interconnected colonies is often called a "super-colony". Resources no longer need to be defended, and the energy previously used for defence is re-allocated to colony expansion. This aspect of little fire ant behaviour is the key to its invasive ability.

Inter-specific aggression

In contrast to the high level of within-species cooperation, little fire ants engage in an aggressive defence of the entire super-colony. Any ant from another species that happens to be within the super colony is overcome by sheer weight of numbers, and it is rare to find colonies of other ant species within areas infested by little fire ants.

Dispersal ability

An invasive organism needs a means to relocate to new environments. Little fire ants do not disperse by flight, but a colony fragment of a few workers and one reproductive queen is all that is needed to establish themselves at a new location. A viable colony fragment is able to fit comfortably into an area smaller than a match-box and is thus easily hidden within cargo, baggage or other possessions. Increasing rates and volumes of human commerce provide the vector needed for little fire ants to move from location to location with little effort. This feature allows them to spread over long distances with little effort, or shorter distances through the movement of items such as potted plants, produce and other risk items.

Mutualisms

Another vital key to the success of invasive ants is their ability to capture and redirect sources of energy to themselves. One very important method these species utilize is through the formation of mutualistic relationships with Homoptera (scales, mealybugs and other plant pests) (Way 1962; Helms and Vinson 2002). Little fire ants "farm" these animals, protect them from natural predators and consume the sugary exudates the insects produce. Of all invasive ant species, little fire ants appear to be one of the most effective at forming and exploiting these mutualistic relationships.

Similar to human agriculture, this "farming" of Homoptera provides the ant colony with an additional energy source not previously available in the environment. This additional energy allows ant populations to grow and spread. The Homoptera populations also become larger because the ants protect them from natural predators, resulting in the availability of even more resources. These mutualistic relationships are one reason for their ability to form populations far more numerous than the ants they displace. Without access to these additional resources, population densities would be much lower.

Impacts of little fire ants

In the Pacific, people, agriculture and the environment are intimately inter-connected. Dwellings and urban structures are located in close proximity to the natural environment and agricultural areas (especially subsistence agricultural areas). Little fire ants profoundly affect each of these sectors.

They are a serious pest of dwellings and urban structures (Fernald 1947, Fabres and Brown jnr 1978, Delabie 1995) and are very difficult to exclude. They infest houses, foraging through homes, stinging people, children and domestic animals. Their stings affect people to varying degrees from causing a painful rash to extreme reactions causing large raised welts.

In external areas around dwellings, they will nest in vegetation as well as on the ground. However, they are easily dislodged from their arboreal homes, and will fall on unsuspecting people and domestic animals. When they become trapped in clothes or the fur of animals, they become alarmed and the alarm pheromones emitted cause all nearby ants to sting in unison.

In areas infested with little fire ants domestic animals are commonly observed with clouded corneas. This condition is known as tropical keratopathy or Florida Spots. It is thought to be caused by entry and growth of mycobacteria within the corneal layers resulting from a physical injury to the eye (Gelatt 1999). There is lot of anecdotal evidence suggesting that little fire ants cause this condition, and this has recently been confirmed by an epidemiological study in Tahiti (Theron 2005).

In natural ecosystems, little fire ants displace other ant species and predate on insects and vertebrates. Often other animals sharing the same habitat simply relocate to uninfested areas to avoid the discomfort of being constantly stung and the reduction in prey items.

Although there are few studies of the total ecological impacts caused by this species, there are numerous reports describing impacts on individual species or species groups (Clark *et al*. 1982, Lubin 1984, Jourdan 1997, Wetterer *et al*.1999, Armbreght 2003, Le Breton *et al*. 2003, Walker 2006, Ndoutoume-Ndong and Mikissa 2007, Beavan *et al*. 2008, Vonshak *et al*. 2010).

Agricultural systems are impacted in two main ways by little fire ants. First, the mutualisms between Homoptera and ants causes explosions of plant pests (Spencer 1941, Delabie 1988, 1990, Delabie and Cazorla 1991, de Souza *et al*. 1998, Souza *et al*. 2008, Fasi *et al*. 2012). This dramatically decreases plant health and productivity. Secondly, the presence of little fire ants makes plant husbandry and harvesting much more difficult. Agricultural workers are constantly stung, making them reluctant to operate in infested locations (Fabres and Brown jnr 1978).

Little fire ants in French Polynesia

History and detection

Little fire ants were first detected in the Tahiti municipality of Mahina in July 2004. According to the entomologist for the French Polynesia Ministry of Agriculture, the first infestation was well-established and may have been present for as long as ten years prior to its discovery (Putoa, pers comm. Feb. 2013). As with many incursions of new species, the origin and pathway of introduction was unclear. However, genetic comparisons of little fire ant infestations worldwide strongly suggest that the source population was located in Gabon, New Caledonia or Guadeloupe in the Caribbean (Foucaud *et al*. 2010).

Initial response (2004-2005)

Once detected, the French Polynesia Ministry of Agriculture (Service du Developpement Rural, or SDR) allocated USD$150,000 for delimiting and controlling of the new incursion. Delimiting surveys identified three infested municipalities (Table 1). These were treated in July and October 2005 with Amdro® an ant bait containing 0.739 % hydramethylnon as the active ingredient. In 2006, chief responsibility for the response to this species passed to the French Polynesia Ministry of Environment (Direction de l'Environnement or DIREN), although the Ministry of Agriculture retained responsibility for quarantine inspections of commodities travelling between islands in French Polynesia. As a result of these regular inspections, little fire ants were detected on a small sailing vessel (a Hobie-Cat) being transported between Mahina and Raiatea island, some 140 miles west of Tahiti. These were immediately treated and destroyed.

Recent response (2006-2013)

The French Polynesia Ministry of Environment became the lead agency tasked with control of little fire ants in 2006. Funding of USD$112,500 was allocated in 2006, USD$650,000 in 2007 and USD$1,250,000 in 2008. No information regarding funding levels for this program were available to the writer for the period 2009-2012.

During the period from 2004 to 2010, more intensive surveys were conducted. Despite the treatment program in place, the number of infested sites detected by survey and public awareness increased from 1 site to 79 sites and the actual infested area rose from 9 hectares to over 780 hectares.

Current response activities

With the exception of the ongoing treatment of a small infestation on Moorea Island, no systematic surveillance or treatment activities are currently being conducted. Actions are limited to responding to public enquiries.

Methods and Materials

Project overview – delimiting survey in Mahina

The main project component addressed by this report is the conduct of a delimiting survey of the municipality of Mahina, Tahiti. This jurisdiction had a population of over 14,000 (www1), approximately 3,500 dwellings and covered 5,160 hectares. A delimiting survey restricted to the urban areas alone would require an estimated field component of 500 person-days with a laboratory and data entry input of approximately 300 person-days. Such a survey was beyond the scope of this project.

However, the French Polynesia Ministry of Environment and Ministry of Agriculture have conducted extensive delimiting surveys over the entire island of Tahiti between 2004 and 2010. These data were mostly collected in a systematic fashion and recorded both textually and graphically. The ministries have made these data available and this section of the report has summarized and analysed available data. Additional information presented in a 2010 review of the little fire ant response in Tahiti (Bossin and Padovani 2010) has also been used.

During the scoping trip conducted 11-15 February 2013, three current or proposed green waste sites were visited within Mahina commune. These were surveyed for the presence/absence of little fire ants by mainly visual searching.

Results

Tahiti and Moorea

The administrative sub-division of the Windward Islands (Tahiti and Moorea) is comprised of 13 communes. These have political and administrative similarities to counties in the United States or shires in Australia. Most data made available by the French Polynesian ministries were summarized by commune. Remaining data have been grouped by commune for the purpose of this report. In 2012, little fire ants have been recorded in ten of these communes (Figure 3).

Surveillance activities

The location, number of infested sites and infested areas were recorded by the Ministries of Agriculture (2004-2006) and the Environment (2006-2012). These data were a combination of systematic surveys and ad hoc responses to public calls. Survey effort differed over time, influencing the datasets (Bossin and Padovani 2010). There are minor discrepancies between datasets. However, together they form a picture of increasing rates of infested sites and areas. During the initial response phase in 2004, little fire ants were detected in the communes of Mahina, Punaauia and Hitiaa O Te Ra. In total there were nine infested sites totalling 178.4 ha (Table 1).

Table 1. Areas identified with little fire ants in Tahiti as a result of initial delimiting survey conducted by the Polynesia Ministry of Agriculture in 2004/5.

Municipality	Number of infested sites	Total infested area (ha)
Mahina	5	146.0
Punaauia	3	22.3
Hitiaa O Te Ra	1	10.1
Total	9	178.4

From 2006, the French Polynesia Ministry of Environment took the lead role in the little fire ant response. Data provided by them have been collated by calendar year. Between 2004 and 2010, the distribution of little fire ants increased steadily from a single site measuring 9 ha to 79 sites with a total infested area of 783 ha (Table 2). These data do not represent the actual infested area as these were influenced by survey effort, intensity and probability of detection;

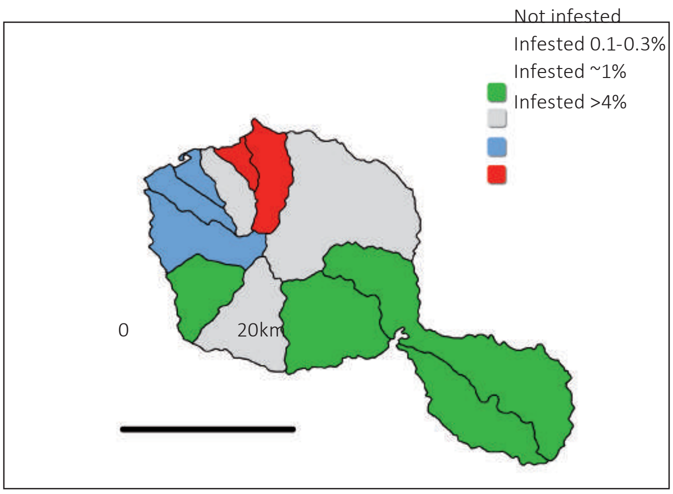

Figure 3. Map of Tahit showing communes where little fire ants have been detected.

therefore they are likely to be under-estimates and may not accurately reflect the rate of spread. Systematic surveys were discontinued in 2010 and data collected subsequently were in response to public enquiries. By the end of 2012, ten communes had little fire ant infestations to varying degrees (Table 3). The percentage of infested land by commune is shown in Figure 4.

Table 2. Number of sites and total area infested with little fire ants in Tahiti between 2004 and 2010.

	2004	2005	2006	2007	2008	2009	2010
Number sites	1	18	23	33	44	76	79
Infested area (ha)	9.1	254.0	267.7	495.6	518.1	778.7	782.7

Treatment activities

Treatment of infested areas commenced shortly after little fire ants were discovered and consisted predominantly of applications of Amdro®, an ant bait containing hydramethylnon 0.739% a.i. (Bossin and Padovani 2010). Data for treatment activities for 2005 were made available by the French Polynesia Ministry of Agriculture and for 2007-2009 by the French Polynesia Ministry of Environment. However, not all data were available at the time this report was prepared. Annual treatment areas by commune are summarized below in Table 4.

Table 3. Area and number of sites infested with little fire ants in the Windward Islands by commune.

Commune	Infested area (ha)	Number of sites
Mahina	481.9	21
Arue	86.8	9
Punaauia	65.1	14
Faaa	41.3	8
Hitiaa O Te Ra	37.1	13
Papara	23.6	2
Papeete	17.7	11
Pirae	4.0	6
Moorea	0.6	1
Taiarapu Ouest	0.5	1
Paea	0	0
Taiarapu Est	0	0
Teva I Uta	0	0
Total	758.0	86

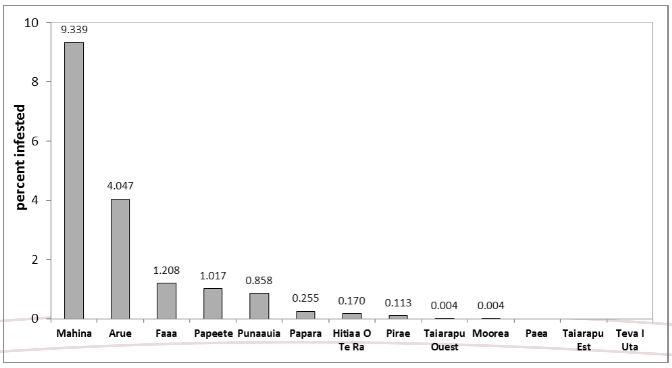

Figure 4. Per cent land area infested with little fire ants for communes in Windward islands administrative sub-division (2012).

Table 4. Areas (ha) treated for little fire ants in Tahiti 2005-2009 by commune.

Commune	7/2005	10/2005	2007	2008	2009
Mahina	146.0	133.4	322.8	551.7	686.6
Arue			42.5	22.8	125.5
Punaauia	22.3	18.1	48.2	68.6	48.1
Faaa			3.2	4.2	39.5
Hitiaa O Te Ra	10.1	10.1	13.3	17.8	21.2
Papara					22.0
Papeete			8.7	20.8	12.2
Pirae			2.9	2.0	4.7
Moorea					
Taiarapu Ouest					
Paea					
Taiarapu Est					
Teva I Uta					
Total (ha)	178.4	161.6	441.9	687.2	961.8

Commune of Mahina

The commune of Mahina was the most severely affected municipality of Tahiti. Over 60% of infested land was located within this commune, almost exclusively in the area south of the main connecting road between municipalities (Figure 5). Within the municipality were a proposed green waste processing site, a proposed municipal waste transfer site and a stockpile of green waste and oversize items (Figures 6a, b) all visited on 11 February 2013.

Current stockpile

The current stockpile of green waste covered a site of approximately 2 ha immediately south of Onohu Beach. The green waste consisted of mostly dead plant material with occasional volunteer banana and coconut plants emerging from the piles (Figure 7). Staff from the French Polynesia Ministry of Environment regularly surveyed this site and have not detected little fire ants there. Visual searching conducted on 11 February did not detect little fire ants. Few ant species were detected, and these were mostly on or near any live plants growing from the stockpile.

Proposed green waste processing site

This site was located approximately 1km south of the current stockpile. Little fire ants were abundant along the road leading to the site, and it was assumed they extended into the surrounding forest.

Proposed Mahina waste transfer station

A level area has been prepared adjacent to the Mahina waste management facility. The purpose of this transfer station is to serve as an initial sorting and staging area for household and recyclable waste. No little fire ants were detected along the boundaries. However, earlier surveys conducted by the Ministry of Agriculture did detect little fire ants immediately to the east of this site.

Estimates of future growth

Future growth can be estimated using a variety of methods, and may be linear or non-linear. Available growth data are not accurate estimates of actual growth in Tahiti because they have been influenced by different survey efforts between 2004 and 2010 (Bossin and Padovani 2010). Assuming growth is linear, simple regression predicts that in 2013, there will be approximately 120 infested sites ($R2$ = 0.9507) spanning 1220 hectares ($R2$ = 0.9531).

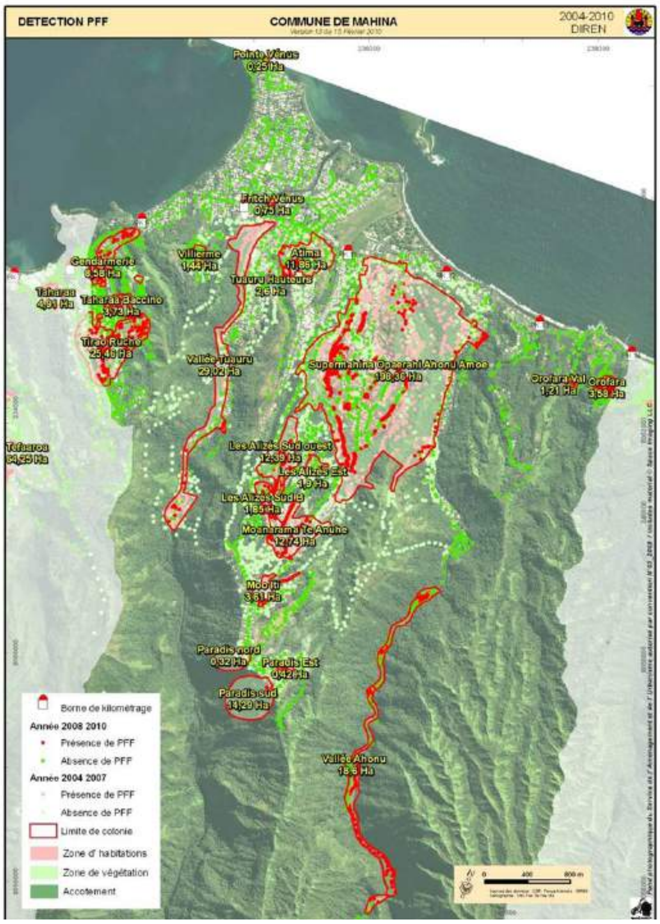

Figure 5. Map of Mahina commune showing survey effort and results. Red dots – LFA positive in 2010, bright green dots – LFA negative in 2010, pink dots – LFA positive 2004-2007, light green dots LFA negative 2004-2007.

Map provided by French Polynesia Ministry of Environment

Figure 6a. The green waste stockpile at the Mahina commune. *©David Haynes/SPREP*

Figure 6b. Site of the proposed green waste processing facility in Mahina. *©CasVanderwoude/SPREP*

Discussion

Distribution in Tahiti

Of the 13 municipal jurisdictions in Tahiti, ten had little fire ant infestations. These ranged from a single infested site of 0.5 ha in west Taiarapu, to 482 infested hectares over 21 sites in Mahina. The majority of infested sites were near areas of human habitation. With time, and the absence of concerted control and containment activities, the degree of infestation will steadily increase.

The future rate of growth will be determined by the following factors:

- The rate of natural spread from each foci;
- The number of dispersal events from each site; and
- The amount and efficacy of containment effort.

Growth within an infested site occurs by natural spread and while actual estimates were not available, this type of spread is measured in meters per year, certainly no more than 100 meters. As colonies produce more workers and queens, they will progressively occupy more and more territory. There are geographic features that will limit natural spread. In regions with arid climates, little fire ants find it difficult to cross large expanses of lawn or bitumen, for example. Typical annual rainfall for Tahiti is 70 inches (1750 mm) with a distinct winter dry season and a wet summer season. Natural spread will be slower between April and October when Tahiti experiences less rainfall. However, given the prevailing climate and abundance of habitat and resources available to little fire ants in Tahiti, natural spread is expected to be rapid.

Dispersal from one site to another can only occur with human assistance. Typically, little fire ants will "hitch" a ride on potted plants, landscaping material, produce or vehicles. In Hawai`i for example, the majority of new infestations occurred through the sale or movement of potted plants. The most important determining factor on the rate of growth was the number of nascent foci and response and containment activities at these locations (Moody and Mack 1988).

Currently, in the absence of public awareness activities and any systematic efforts at mitigating little fire ant infestations, the number of infested sites is expected to increase rapidly.

Containment activities against this species rely on the use of baits (a food matrix with small amounts of a suitable pesticide) and application of broad-spectrum residual pesticides. Baits are considered the most effective control option while pesticide applications are useful as barriers and protection of homes and other structures. Many baits designed for use against red imported fire ants are reasonably effective against little fire ants, however there are three factors that limit efficacy. Firstly, not all baits are palatable to little fire ants. It appears that some active ingredients effective against red imported fire ants are actually repellent for little fire ants. Secondly, Tahiti's tropical climate features frequent rainfall. Once the baits become wet, they are no longer effective. Ideally a dry period up to 24 hours post-treatment is sufficient for good bait uptake. Finally, little fire ants nest in trees as well as on the ground. Granular baits are almost impossible to apply to vegetation so a substantial component of little fire ant colonies remains unaffected by bait treatment.

Undoubtedly, the commune of Mahina was the worst affected jurisdiction with approximately 21 infested sites covering 482 hectares. This represents over 9 per cent of the total land area of Mahina. However, a large section of the municipality was virtually free from the little fire ant. The urban area north of the main belt road contained only a single infested site. If an effort is made to prevent the spread of little fire ant to new locations in this suburb, it could be kept relatively ant free for some time.

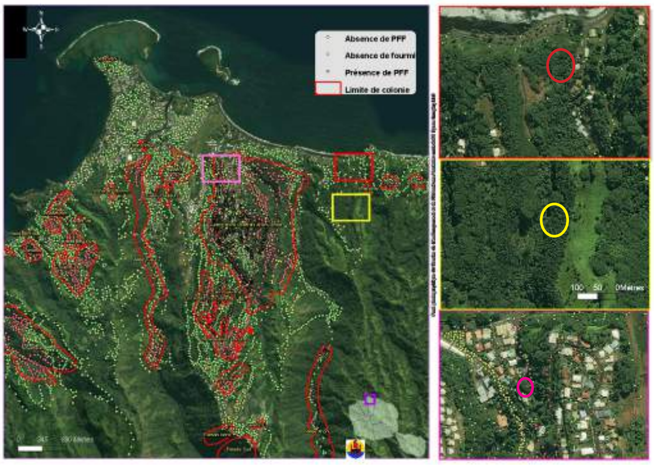

Figure 7. Green waste sites visited in Mahina: red circle, current stockpile of green waste and oversize items; yellow circle, proposed green waste processing site, pink circle, proposed transfer station. Red dots – LFA positive in 2010, bright green dots – LFA negative in 2010, pink dots – LFA positive 2004-2007, light green dots LFA negative 2004-2007.

Map provided by French Polynesia Ministry of Environment

Sites with high ecological, economic and cultural values

Some areas have greater ecological, economic and social value than others and Infestation of these sites is likely to have a greater impact. For example, tourist beaches, intact natural ecosystems, and industries such as nursery production all have a greater impact potential. For these areas, a program of early detection and rapid response will provide great benefits. Early detection carries a great economic benefit as the size of an infested area will determine control costs and more importantly, the probability of a successful outcome. Investment in early detection and response for such areas will yield the greatest dividends.

Nascent foci and small infestations

Newly established and small infestations play a very important role in the rate of growth of invasive species (Moody and Woods 1988). They are also relatively easy to control and the probability of successful "spot" eradications over small sites is good. For example, a small infestation of little fire ants was recently eradicated in Maui (Vanderwoude *et al.* 2010) at a low cost. A focus on suppressing smaller and more isolated infestations will yield the greatest returns for slowing the spread of this species.

Options for control and containment

A detailed discussion of control methods and containment options are covered in subsequent reports. However, there is potential for several strategies that would minimize the impact of little fire ant on French Polynesia. Within a broader response strategy, the following points could be considered:

Preventing spread to neighbouring islands

The ocean barrier between Tahiti and the other islands that make up French Polynesia offer an excellent opportunity to limit the spread of this ant. The French Polynesia Ministry of Agriculture has a comprehensive domestic biosecurity strategy in place. The resources expended on this strategy have enormous benefits in limiting spread of all biosecurity threats including little fire ants. Further investment in this activity is likely to increase these benefits. As an example in 2006, a small sailing boat was shipped to Raiatea island from Mahina. Inspectors detected little fire ants on this boat and quickly treated the craft, preventing an almost certain infestation on Raiatea.

Response planning

An essential component of any biosecurity strategy is effective response planning and provision of training associated with response activities as a preparation for biosecurity breaches. An emergency response plan for invasive ants should include the legislative authority to act, the availability of funding and human resources, organizational structure, standard operating procedures for detection and response, diagnostic capability and availability of treatment products.

Public outreach and awareness

A greater public awareness of the ways that little fire ants can be moved to their properties will likely reduce the number of infestations. Additionally, education relating to effective control methods will not only produce better treatment results for individuals, it will also reduce pesticide usage. Many pesticides available over the counter in Tahiti persist in the environment and have the potential to pollute the delicate reef ecosystems this island is so well known for. The impact of public outreach and awareness is likely to be greater when managed by specialist outreach personnel.

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Chapter 2: Integrated waste management strategies to minimise the risk of transportation of the little fire ant in Tahiti, French Polynesia

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Summary

The electric ant or little fire ant, *Wasmannia auropunctata*, is a small ant native to Central and South America which has been introduced into eight Pacific Island groups. It is considered to be the greatest ant species threat within the Pacific Region. Although its official discovery in Tahiti was in 2004, it is likely that the little fire ant has been present in Tahiti for much longer. The center of contamination in Tahiti is the northern Mahina commune. Initial treatment and monitoring initiatives to combat the ant invasion were carried out between 2005 and 2009, but were discontinued in 2010.

Little fire ants are known to infest green waste as well as oversized waste left out for collection. To counter human assisted transportation of little fire ants, the movement of green and oversize waste from the Mahina commune to other areas of Tahiti was prohibited in 2006. However, this ban has hindered effective waste management in the Mahina commune, and resulted in adverse environmental impacts from the continued use of an unregulated dumpsite used to temporarily dispose green waste and oversize waste.

Green waste from the Mahina commune could be composted under controlled conditions at a local site to minimise or eliminate any accidental ant transportation. Composting green wastes under controlled conditions elevates internal compost temperatures above 60oC for a sufficiently long duration to kill any insect pests (including Wasmannia) in the composting vegetation. Strict adherence to routine quality assurance measures at the composting site including ant baiting and monitoring, compost pile temperature logging, adherence to minimum compost row separation, use of soil pesticide barriers, runoff monitoring and regular sterilization of all machinery and tools involved in composting operations would ensure that the ant was not accidentally transported in final compost products.

Collected metallic oversize waste to be exported overseas for recycling also present a potential source of ant contamination and transport. Oversized waste collected from elsewhere in Tahiti are currently compacted and then fumigated with methyl bromide to kill any pest species (including the little fire ant) prior to export. Arrangements to also treat oversized waste collected from Mahina with the fumigant should be investigated. In parallel, controlled trials should be undertaken to assess the efficacy of heat sterilization achieved through long-term sunlight exposure on metal shipping containers and their contents as an alternative to continued use of methyl bromide fumigation of compacted, oversized waste.

All compost produced in Tahiti is also currently fumigated with methyl bromide prior to sale. The necessity for this should be reviewed, and a public education campaign developed to explain any changes to ant control measures and to help market the Mahina compost product.

An assessment of any legislative changes required for improved green waste and oversized waste management in Tahiti should also be completed, and funding sought for the remediation of the Mahina unauthorised dumpsite following its closure.

Background

The little fire ant

The little fire ant (*Wasmannia auropunctata*), is a small, forest dwelling ant native to Central and South America (Figure 1). It has been introduced to parts of Africa, North America and into eight Pacific Island groups (including the Galápagos Islands, Guam, Hawaii, New Caledonia, Vanuatu, Tahiti and the Solomon Islands) and to north-eastern Australia (Wetterer and Porter 2003). Where it is introduced, the ant is blamed for reducing species diversity, reducing overall abundance of flying and tree-dwelling insects, and eliminating arachnid populations. It is also known for its painful stings. It causes severe direct impacts on humans by reaching high densities in settlements, farmland and natural habitats, and poses significant risks to the environment and economies of trading and transport partners if introduced (Fernald 1947, Fabres and Brown 1978, Delabie 1995). The little fire ant is considered to be the greatest ant species threat within the Pacific Region.

Figure 1. The little fire ant (*Wasmannia auropunctata*) infesting a leaf. *©David Haynes/SPREP*

The Tahitian Problem

Although its official discovery in Tahiti was in 2004, the little fire ant is likely to have been present at least 10 years earlier. The center of contamination in Tahiti is the Mahina commune (Figure 2). A major introduction route of the little fire ant can be through the movement of green waste and plant material. Controlling green waste and plant movements to minimize the spread of the ants is therefore a critical, albeit very difficult community management issue connected with management of the little fire ant. The importance of this problem was recognized in 2012 by the funding body Fonds Pacifique.

The fund allocated a €110,000 grant to SPREP and the Mahina commune to develop strategies to improve waste management practices to minimize the ant's spread through the movement of green waste. Additional work under the grant will develop model ant biosecurity strategies to improve invasive species management in French Polynesia, as well as for the Pacific more generally.

Introduction

Little fire ants in Tahiti

Little fire ants have been introduced into a number of Pacific countries including French Polynesia, Guam, Hawaii, New Caledonia, Papua New Guinea, the Solomon Islands, Vanuatu and Wallis and Futuna (Vanderwoude 2013). The invasive ants were first detected in the Tahiti commune of Mahina in July 2004, although the first infestation may have been present for as long as ten years prior to its discovery (Vanderwoude, 2013). Genetic studies suggest that the source population for the Tahiti infestation was located in New Caledonia (Foucaud *et al*. 2010). Initial treatment and monitoring initiatives to combat the ant invasion of Tahiti were carried out between 2005 and 2009, but were discontinued in 2010. Ten communes had recorded ant infestations by 2012, with the Mahina commune having the largest number and extent of infestation. An increase in the area of little fire ant infestation occurs through the expansion of colonies, and while actual estimates are not available, the rate of this type of spread is typically slow, and measured in tens to hundreds of meters per year. In contrast, dispersal via human transport enables rapid colonization of new uninfected sites, and dispersal from one infested site to another can occur rapidly and over large distances (Vanderwoude 2013). With time, and in the absence of concerted control and containment activities, the extent of little fire ant infestation will almost certainly increase in Tahiti.

The Mahina commune

The Mahina commune is the fifth largest in French Polynesia, with a population of around 14,500 (2007). It is located on the northern side of the island of Tahiti and contains over 60 % of all Tahitian little fire ant infestations. These are believed to be contained in the area south of the main connecting road between municipalities, which has provided a barrier to ant movement. Infestations are believed to occur across 9% of the total Mahina land area, and a majority of infested sites are located near areas of human habitation. A major vector for ant movement is via the transportation of green and oversized (bulky) waste, and to counter this, a prohibition has been placed on the movement of these waste types from the infested Mahina commune to other un-infected areas of Tahiti. This ban is compromising efficient and cost effective rubbish disposal in Mahina commune, and is likely to be contributing to impacts from the continued use of an unregulated dumpsite for local green and oversized waste disposal.

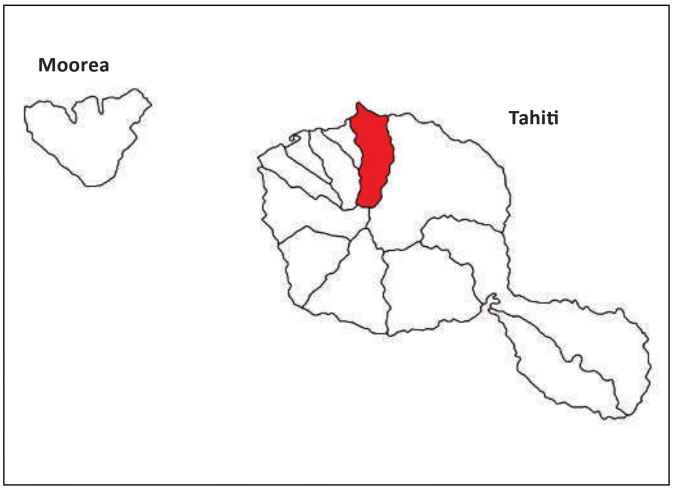

Figure 2. Location of Mahina commune on the island of Tahiti, French Polynesia (red-shaded area).

Waste Collection

Current waste collection and transfer services in the Mahina commune

Responsibility for household waste collection services lies with the Mahina municipality (Table 1). Households in the Mahina commune are required to separate wastes into 'recyclable' and 'non-recyclable' bins prior to collection (Figure 3), and green waste and oversized waste is placed separately in uncontained heaps on the roadway for collection (Figure 4). Estimates of the daily volume of waste produced by the Mahina commune are 60 m^3 per day for recyclable waste, and 90 m^3 per day for other waste. Household rubbish is collected and transported to the Socièté Environmental Polynèsien (SEP) Centre for Recycling and Transfer (CRT) in Papeete, where it is consolidated and transferred to the Poihoro Sanitary Landfill in larger trucks for final disposal. Recyclable waste from Mahina commune is also collected and transported to the CRT for sorting, baling, and export to recycling markets in Asia and New Zealand. In the near future, domestic rubbish (excluding green and oversized waste) collected from Mahina households will be taken to a new Mahina transfer station (which is currently under construction). Collected rubbish will be transferred into large bins with 20 m^3 and 30 m^3 capacities prior to transport to the Poihoro Sanitary Landfill for final disposal.

Figure 3. Household rubbish and recycle bins, Mahina. *©David Haynes/SPREP*

Figure 4. Household green waste, Mahina. *©David Haynes/SPREP*

No little fire ants have been detected within this new Mahina transfer station site (Vanderwoude 2013).

Table 1. Summary of Mahina waste collection services, 2013.

Wastes	Collection Frequency	Responsibility
Recyclable waste (including aluminium and tin cans, plastic bottles, Tetra Pak cartons, newspapers and cardboard)	Once per week	Mahina municipality
Non-recyclable waste	Twice per week	Mahina municipality
Oversized bulky waste	Once per month	Mahina municipality
Green waste	Twice per month	Mahina municipality
Glass bottles (via public drop boxes)	As needed	Mahina municipality

Figure 6. Mobile scrap metal compactor, CRT center.

Current waste disposal in the Mahina commune

Oversized (bulky) waste disposal

Oversized (bulky) waste from Mahina residences are placed on the roadway for monthly collection. Due to the potential for contamination of this type of rubbish by little fire ants, a ban has been imposed by the Direction régionale de l'Environnement (DIREN) on its movement out of little fire ant infested areas.

Consequently, oversized wastes have been dumped at an unauthorized Mahina dumpsite since 2006 (Figure 5). In contrast, a scrap metal compactor is relocated to other Tahitian communes by SEP to crush end-of-life vehicles and other oversized wastes prior to export to New Zealand on an as needs basis (Figure 6). The cost of metal recycling from these other communes is recovered from the import duty placed on all consumer goods (2%), and from the proceeds from the sale of the exported scrap metal.

Green waste disposal

Green waste from Mahina cannot be taken to a national composting facility in Poihoro and operated by Technival due to a ban imposed by the DIREN on the movement of vegetation out of little fire ant infested areas. Consequently, green waste from Mahina commune is currently collected twice per month from Mahina residences, and has been dumped at a local unauthorized site since 2006 (Figure 5). The unauthorized dumpsite covers an area of approximately 0.55 hectares (1.35 acres). There is some attempt at segregation of waste at the dumpsite, with green waste dumped on the eastern edges of the site, and oversized items on the western side. Illegal and uncontrolled dumping of household waste also occurs at this site, creating a mixed stream of rubbish at the dumpsite. Leachate runoff from the site is also unmanaged and presents a potential risk to adjacent waterways. As the dumpsite land has been committed specifically for a public cemetery, relocation of the dumped waste and rehabilitation of the site is of high importance. It has been suggested that little fire ant colonies may not have yet established at the site because of their sensitivity to the site's exposed, sunny conditions (Vanderwoude 2013).

Current green waste collection and disposal in other communes

Household waste from at least three Tahitian municipalities (Papeete, Pirae, and Arue) are collected door-to-door and transported for processing at the CRT in Papeete (Figure 7). Green waste is not accepted at the CRT. Green waste is collected from Tahitian municipalities (except Mahina commune) by Technival for compost production. Following household collection, this green waste is reduced down to 80mm pieces in a mobile hammer mill chipper to minimize transport costs (Figure 8). The crushed green waste is then transported 50 kilometres in 30 m^3 bins to the Technival composting facility in Poihoro. Approximately 12,000 tonnes (50,000 – 60,000 m^3) of green waste is collected by Technival and processed annually at the Poihoro composting facility (Figure 9).

Figure 5. Unauthorised green waste dumpsite, Mahina. *©David Haynes/ SPREPSPREP*

Figure 7. Papeete CRT waste transfer station. *©David Haynes/SPREP*

Green waste composting

Compost is organic (green) matter that has been decomposed and used as a fertilizer and soil improver. The decomposition of organic matter to form compost is aided by shredding the plant matter, maintaining an optimal moisture level, and ensuring proper aeration (usually by regularly turning the mixture). Micro-organisms, including fungi and bacteria break down the organic material in a process that releases heat and carbon dioxide, as well as nitrites and nitrates via nitrification.

The Technival composting facility

The Technival composting facility encompasses a total area of 5 hectares of a site at the southern end of Tahiti in Poihoro (Figure 9). The ground surface used for the composting process is impervious (it is about 80 % waterproof), and covers an area of 8,000 m^2 of bitumen overlaid with liquid cement. The composting surface is currently being expanded by 5,000 m^2 to accommodate co-composting of sewage sludge and green waste.

Figure 8. Technival composting facility green waste chipper. *©Technival*

Figure 9. Paihoro SEP landfill and Technival composting facility. *©Google Maps*

The Technival composting process

Green waste is placed into open piles for 6-8 months at the Technival composting facility (Figure 10). During the first few months, piles are turned every 3 weeks using a loader, achieving temperatures in excess of 65°C for 3 days or more (as measured using manual temperature probes). During the maturation phase, two piles are combined and turned once every 2 months until fully composted. Composting procedures at the facility are believed to comply with EU compost hygiene standards (i.e. compost temperature consistently greater than 65oC for at least 5 days; >60°C for at least 7 days; or >55°C for at least 14 days). Sewage sludge containing 30% total solids is also co-composted with green waste at the site. Prior to composting, collected sewage sludge is stored in Papeete for approximately 1 week, during which time core temperature reaches 85°C, before transportation to the Technival Poihoro composting facility. The piles of sewage sludge are mixed with green waste at Poihoro and covered with a green breathable waterproof textile to regulate moisture. The piles are forcibly aerated, and are turned every 3 weeks. Under these conditions, core pile temperatures reach over 80°C, over 70°C, and between 60-65°C after the first three turnings respectively. Mature compost can be prepared in only 3 months using a green waste and sewage sludge mixture through this process. The compost produced from green waste and sewage sludge is used only for "professional" activities such as grass production and in nurseries. This compost is not distributed to the public or used in production of food crops.

Compost sterilisation

The bulk compost destined for use in Tahiti is currently required to be treated with methyl bromide, and this sterilisation is performed as a free service provided by the Department of Agriculture at the Papeete port precinct.

Compost product usage

About 50-60 % of the finished compost produced by Technival from green waste is sold in bulk, usually in 1 m^3 bags at the rate of XPF 9,000 (US$98) per tonne. The remaining product is sold as "organic compost" or mixed with peat moss imported from Canada, and with pumice and chemical fertiliser from New Zealand, to make a special potting mix sold at XPF 800 (US$9) per bag (Figure 11). Approximately 60% of Technival's income is derived from invoicing the municipalities for the collection and removal of green waste, and 40 % comes from the sale of the compost and potting mix.

Recommendations for improved green waste management in Mahina commune

While there is very little information on the fate of little fire ants in active compost heaps, International quarantine requirements operate on the premise that insects cannot survive elevated temperatures (i.e. greater than 55 °C) for extended time periods (such as those attained in well-operated compost windrows). The recommendations for green waste management in Mahina commune therefore

Figure 10. Compost windrow, Poihoro. *©David Haynes/SPREP*

Figure 11. Technival retail compost bags. *©David Haynes/SPREP*

centre on the optimization and careful management of the green waste composting process to eliminate the little fire ant through temperature elevation. This will allow the green waste from Mahina and other ant-infected areas to be used productively without risk of spreading the invasive species through green waste management.

Identification of a Mahina green waste composting site

Technival has the additional capacity and is prepared to treat green waste collected from Mahina commune. It is estimated that green waste sourced from Mahina would account for an annual additional 3,000 tonnes or 15,000 m^3 of raw material that could be composted. This is 25 % of the current production capacity. Technival would prefer to compost potentially ant infested green waste from Mahina in Mahina, to maintain a separation of operation from Technival's current little fire ant free composting facility at Poihoro. This would preserve the good image, reputation, and public good-will built up by Technival over the years.

Land availability for a new composting facility within the Mahina commune is limited, and only two potential composting sites within Mahina have been identified. The first is located in a forested area near the current unauthorized Mahina dumpsite (Figure 11). The area is infested with little fire ants, and is located close to a stream. Any compost produced on this site would be at risk of infestation from the little fire ants and would require stringent site maintenance and controls to eliminate or reduce the risk of infestation. Furthermore, the site would require protective measures to reduce the risk of tropical monsoonal flooding from the nearby stream. This is of critical importance as little fire ants can be transported great distances in floods (Wetterer and Porter 2003).

The second potential site is an abandoned dumpsite, which was previously operated as a composting site between 2002 and 2010 (Figure 12). It is reported that some composting infrastructure is already in place, although much of it appears to be now covered with waste materials. As with the first site, this location is infested with little fire ants and would require similar maintenance and controls. Operating a future compost facility at this location would include the added benefit of the concomitant remediation of an abandoned dump.

Recommendation 1: Select and prepare a preferred composting site for all green waste generated in Mahina commune

Development of quality assurance procedures for green waste collection and transport

Collection of data on areas affected by the little fire ant in Tahiti was discontinued in 2009. It is therefore difficult to identify which areas of Tahiti, and specifically, which areas of Mahina commune may be free of the little fire ant. It must therefore be assumed that all transported green wastes from the Mahina area contain little fire ants. It is essential that potentially contaminated waste is transported and handled in a manner that does not contribute to the accidental spread of the little fire ant.

Recommendation 2: Development and testing for standard operational procedures to minimize the spread of little fire ants through green waste transportation and crushing (including cross-contamination from collection equipment).

Development of optimal green waste composting process to eliminate little fire ants in composting green waste.

There is very little information available on best practice for green waste composting in the presence of little fire ants. The Queensland State Government (Australia) recommends composting in piles no more than 10 metres wide to ensure even pile temperatures, maintenance of minimum distances (5 metres) of compost piles from the perimeter of the storage area, attainment of minimum compost pile temperatures (55 ^{o}C for a minimum of 3 days) to kill fire ants; and a minimum spacing of 10 metres between windrows to minimise potential ant contamination between piles (DAFF 2012). In this absence

Figure 11 Proposed Mahina composting site. *©David Haynes/SPREP*

Figure 12. Disused Mahina composting site. *©David Haynes/SPREP*

of information, an investigation should identify the combination of conditions that best achieve a 100 % kill rate for little fire ants during the composting process in Tahiti including:

- Minimum compost temperature required to kill all fire ants;
- The most appropriate and cost-effective composting method (e.g., in-vessel, open windrows, semi-enclosed (or trough) windrows) to achieve these temperatures throughout the compost; and
- Comparative quality of the compost produced under the various experimental conditions designed to eliminate little fire ants.

Recommendation 3: Design and complete trials to identify cost-effective composting conditions and methods for eradicating little fire ants from green waste while still achieving a quality compost product suitable for commercial and household uses.

Development of composting site quality assurance procedures

Implementation of routine, cost-effective quality assurance procedures during the production of compost from green wastes will ensure that compost is ant-free, and will assure regulators and consumers that the final compost product does not represent a biosecurity threat. Routine assessment of the success (or otherwise) of composting biosecurity strategies can be completed to guide management strategies for the composting operation. For example, the Queensland State Government (Australia) recommends 3 monthly pesticide treatment of the composting perimeter with a 30cm barrier of the insecticide chlorpyrifos; and that the treated area must be kept free of material that could form part of an untreated 'bridge' to the composting green waste (DAFF 2012). Compost products also need to be protected from little fire ant re-infection at the completion of the composting process. The investigation should also identify the combination of actions that ensure that the composting and compost storage area remains ant free including:

- Recommendation on the most appropriate chemical barrier and its application rates to eliminate little fire ant migration between composting piles or between the surrounding environment and the composting facility ;
- Environmental monitoring criteria to determine potential contamination risks from the use of boundary chemicals;
- Investigation and recommendation on optimal storage protocols for composted material; and
- Little fire ant baiting and monitoring protocols within the composting facility .

Recommendation 4: Design and complete trials that identify cost-effective actions to prevent re-infection of compost with little fire ants during, and following the composting process.

Optimize mature compost storage and sterilization to eliminate little fire ant transport in the distribution of the final product

Ensuring the final sterility of compost products is critical. Tahitian compost is currently exposed to a methyl bromide treatment to ensure the sterility of the compost prior to use. Open bags of compost are transported to the Papeete port precinct where they are placed in a container and exposed to methyl bromide for 12 hours before being sealed for sale on the domestic market. The necessity of this final sterility step for compost is currently untested.

Recommendation 5: Complete an assessment of the legislative and biosecurity necessity for methyl bromide sterilisation of compost products.

Develop a compost marketing strategy to ensure uptake of the Mahina compost by the Tahitian community

The sustainability of a green waste composting programme for Mahina commune is dependent on a stable (domestic) market for the compost product. A compost marketing strategy would identify market demand (locally and regionally), assess public perceptions of compost produced from little fire infested green waste, and assess specific steps (if required) to promote public acceptance of the compost product.

This could also include recommendations for innovative compost marketing strategies such as subsidised distribution of Mahina commune compost at the commencement of the programme.

Recommendation 6: Develop an innovative marketing and communication plan for compost products to ensure expanding compost sales of Mahina compost products.

Recommendations for bulky (oversized waste) management

There is very little information available on best practice for management of oversized waste in the presence of little fire ants. Strict adherence to routine quality assurance measures associated with oversized waste collection and compaction could help ensure that the little fire ant is not transported in metal and other oversized wastes following collection.

Development and dissemination of public guidance on bulky waste

Detailed guidance for residents and the recycling industry on the management of oversized waste needs to be developed and disseminated. This information will minimise the potential transportation risk of little fire ants in collected oversized waste.

Recommendation 7: Development and testing of standard operational procedures to minimize the spread of little fire ants through oversized waste collection, transportation and compaction (including cross-contamination from collection equipment).

Development of quality assurance procedures for sterilization of oversized waste.

Oversized waste should be sterilised following collection and compaction to remove any associated little fire ants. The sterilised waste should then be stored in a secure, ant free location that has regular ant surveillance and monitoring in place until exported. There are likely to be only two practical alternatives for sterilization of oversized wastes: methyl bromide treatment or heat treatment.

- Methyl bromide is an organo-bromine compound. As a fumigant, it is typically used in concentrations of 48 g/m^3, which is about 13,000 parts per million (ppm). At this concentration, methyl bromide is acutely toxic to a wide range of insect pests, plants, animals and people. It was used extensively as a pesticide until being phased out by most countries in the early 2000's as it is a potent ozone depleting substance. Quarantine and pre-shipment use of methyl bromide for pest control is not controlled under the Montreal Protocol.
- Dry heat treatment is an alternative to the use of methyl bromide. Depending on the product, the rate for heat treatment may range from 55°C to 85°C for 10 minutes to 15 hour intervals, which are the temperatures and times approved by Biosecurity New Zealand. Insects are usually unable to survive even short exposure (less than 24h) to temperatures above 50°C (Hosking 2002). Heat treatment has been accepted as a quarantine treatment for logs and timber to be shipped to the USA and many other countries for many years (e.g. USDA 1996). The general specification has been to reach a core temperature of 71°C for 60 minutes. Currently 56°C for 30 minutes core temperature is sufficient for wood packaging.

Recommendation 8: Complete controlled experiments to determine the efficacy and cost-effectiveness of natural heat (achieved through long-term sunlight exposure on metal shipping containers and their contents) and artificial heat treatment of oversized wastes to eliminate little fire ants as an alternative to continued use of methyl bromide fumigation of compacted, oversized waste.

Development of national standards and regulations (for review) that will contribute to reducing the spread of little fire ants through improved waste management activities across French Polynesia.

Recommendation 9: Draft national standards and regulations (for review) that will contribute to reducing the spread of little fire ants through improved waste management activities across French Polynesia.

R**emediation of the unauthorised Mahina commune dumpsite.**

Recommendation 10: Discontinue the use of the unauthorised dumpsite in Mahina commune as soon as possible and remove all waste (green waste, oversized waste and other waste) and remediate the site.

Cost estimate for green and oversized waste recommendations

Recommendation	Activity	Cost	
($US)	Partners		
Recommendation 1	Select and prepare a preferred composting site for all green waste generated in Mahina commune	$5,000	Pae Tai-Pae Uta
Mahina commune			
Recommendation 2	Development and testing of standard operational procedures to minimize the spread of little fire ants through green waste transportation and crushing	$5,000	SEP
University of Hawaii			
Recommendation 3	Design and complete trials to identify cost-effective composting conditions and methods for eradicating little fire ants from green waste while still achieving a quality compost product suitable for commercial and household uses.	$10,000	DIREN Technival University of French Polynesia
Recommendation 4	Completion of trials to identify cost-effective actions for securing a composting site from re-infection with little fire ants during, and following the composting process:		
Windrow temperature monitoring			
Ant monitoring protocols			
Ant barriers			
Pesticide runoff monitoring	$6,000		
$10,000			
$2,000			
$2,000	DIREN		
Recommendation 5	Complete an assessment of the necessity for post compost production methyl bromide compost sterilisation	$10,000	DIREN
Recommendation 6	Develop an innovative marketing and communication plan for compost products	$3,000	Social marketing experts, SPREP
Recommendation 7	Development and testing of standard operational procedures to minimize the spread of little fire ants through oversized waste collection, transportation and compaction	$5,000	
Recommendation 8	Complete controlled experiments to determine the efficacy and cost-effectiveness of heat treatment of oversized wastes to eliminate little fire ants.	$10,000	SEP
University of French Polynesia			
Recommendation 9	Draft national standards and regulations for review that will contribute to reducing the spread of little fire ants through improved waste management activities across French Polynesia.	$5,000	SPREP DIREN
Recommendation 10	That the use of the unauthorised dumpsite in Mahina be discontinued as soon as possible and that all waste (green waste, oversized waste and other waste) be removed and the site remediated.	$55,000	Mahina commune
DIREN			
Project management and support	SPREP Waste Management and Pollution Control Division missions to supervise work of consultants and provide technical assistance (two 1-week missions)	$7,000	SPREP
	ESTIMATED TOTAL ($US)	$135,000	

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Chapter 3: Considerations for eradication, containment and long-term monitoring of little fire ants in Tahiti

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Summary

Little fire ants (*Wasmannia auropunctata*) were first detected on the island of Tahiti in French Polynesia in 2004. Since that time, this pest has spread across the island, with the majority of infestations located on the north and north-west coastlines. Despite concerted eradication efforts to eradicate by response agencies, little fire ants continue to spread, causing ecological, economic and social impacts.

This report analyses current distribution data and existing knowledge of little fire ant behaviour in invaded environments to prioritize treatment and monitoring efforts in order that limited resources are best utilized to reduce the impacts of this pest. Nine recommendations for the strategic response to this species are provided:

- Eradication efforts should focus on eliminating small (<1 ha) infestations and if resources permit, infestations sized 1-5 hectares.
- Containment activities should focus on larger (>5 ha) infested sites.
- Further research is needed to quantify the rates of spread for little fire ants on Tahiti.
- Known pathways and vectors for spread of little fire ants on Tahiti should be monitored and risk minimization efforts should target these pathways.
- Resources should be allocated to enhanced domestic quarantine inspections for risk items being transported to neighbor islands.
- Domestic points of departure, especially the sea port and cargo handling facilities should be surveyed frequently to ensure these sites are free of little fire ants
- International points of departure, especially the sea port, airport and cargo handling facilities should be surveyed frequently to ensure these sites are free of little fire ants
- Resources should be made available for enhanced international out-bound quarantine activities to monitor and inspect cargo, personal possessions and empty shipping containers bound for international destinations.
- Resources should be allocated to the development and implementation of a targeted outreach strategy designed to identify new infestations and reduce the risks associated with known little fire ant vectors.

Background

Little fire ants (*Wasmannia auropunctata*) are an established and expanding invasive pest on the island of Tahiti. This species poses a serious threat to the economy, ecological health and social well-being of French Polynesia and its inhabitants. Once established, little fire ants form dense three-dimensional supercolonies that cover the ground, vegetation and tree canopies. Ants nesting in trees are easily dislodged by wind and other minor disturbance and often fall from their arboreal homes onto people and animals below, stinging their victims and causing blindness in domestic animals. In natural ecosystems, they prey on, or drive out native fauna, leaving an ecosystem depleted of much of its pre-existing animal life. The mutualisms formed between little fire ants and Homoptera cause crop losses in agriculture and declines in plant health for native ecosystems.

Ten of the 13 municipalities within the administrative sub-division of the Windward Islands were infested with little fire ants. The most recent systematic survey was conducted in 2010, resulting in the documentation of 79 infested sites covering 782.7 hectares. This was despite extensive control efforts undertaken between 2006 and 2010. The municipalities of Mahina (9 % of land area) and Arue (4 % of land area) were the most heavily infested. This species will spread in future years, most likely infesting a majority of land adjacent to human habitation or disturbance. Eventually it will also invade natural ecosystems.

Scope and purpose

This report is one of a series of reports that focus on the issue of little fire ants in French Polynesia. The specific purpose of this report was to provide recommendations and standard operating procedures for containment or eradication of this species and for the strategic monitoring of their spread within the island of Tahiti.

Current distribution of little fire ants in Tahiti

Since its discovery in 2004, little fire ants have spread rapidly through the island of Tahiti and onto neighbouring Moorea. Over 86 current known infestations exist, covering 758 hectares (Table 1). The most heavily infested municipalities are in the northern and western part of the island of Tahiti (Figure 1). This distribution is expected to grow as little fire ants are accidentally transported to new locations.

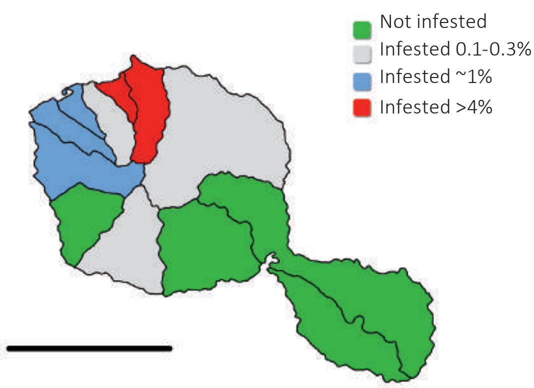


Figure 1. Map of Tahiti showing mean density of infested land (2012).

Little fire ants spread through natural expansion (lateral spread or "budding") and "jump dispersal" (spread mediated by human activity). Once a little fire ant colony becomes established in a new location, the colony grows and expands. The main mechanism for natural expansion is via "budding". This occurs when a newly inseminated queen, accompanied by some worker ants, establishes a new satellite colony. Usually the new colony is located only a short distance (less than 5 metres) from the parent nest. The colony remains connected to the parent nest and acts as a satellite colony. The rate of natural spread depends on availability of suitable nesting sites, foraging areas and availability of food.

It is difficult to predict the exact rate of colony expansion as each site will have different characteristics. However, in suitable sites, spread would be measured in tens of metres per year. Figure 2 shows the rate of expansion of a single colony with spread rates of 10, 20 and 30 metres per year. If spread of a single colony is within these rates, it is reasonable to assume each separate infestation will grow to cover between 3 and 30 hectares over a ten year period.

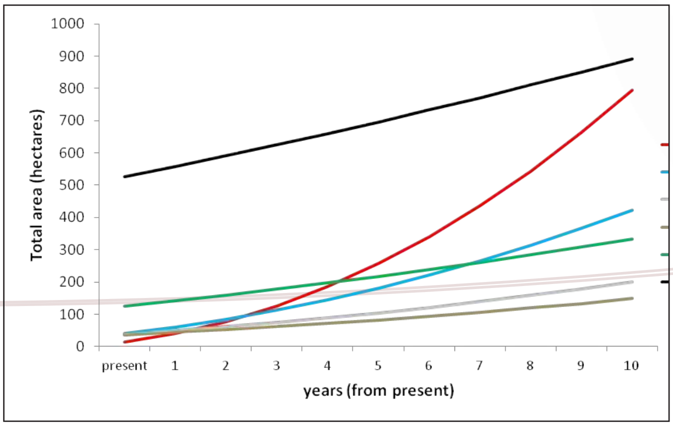
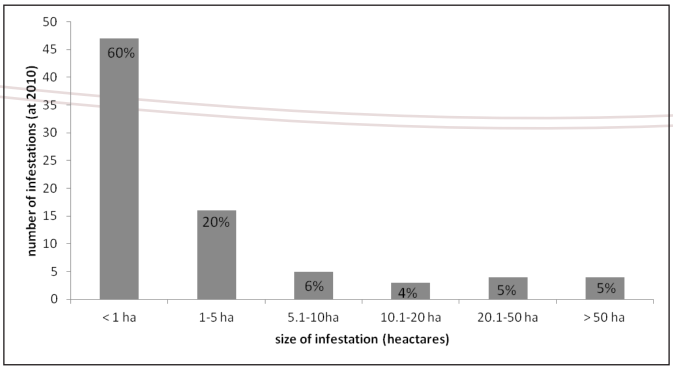


Table 1. Current (2012) infested area and number of sites with little fire ants in Tahiti.

Commune	Infested Area (ha)	Number of sites
Mahina	481.9	21
Arue	86.8	9
Punaauia	65.1	14
Faaa	41.3	8
Hitiaa o te Ra	37.1	13
Papara	23.6	2
Papeete	17.7	11
Pirae	4.0	6
Moorea	0.6	1
Taiarapu (west)	0.5	1
Paea	0	0
Taiarapu (east)	0	0
Teva i Uta	0	0
Total	758.0	86

Little fire ants can also disperse over longer distances when a colony or a colony fragment is transported to a new location. This form of spread is facilitated primarily by human-assisted means, when items harbouring little fire ants are moved to new locations. To a lesser extent, jump dispersal can also be caused by natural events such as rafting along flooded waterways, landslides and similar events.



The French Polynesia Ministry of Environment conducted an extensive survey and mapping project in 2010. Using those data, approximately 80% of all recorded infestations were smaller than 5 hectares, and 60% of these were less than 1 hectare in size (Figure 3).

Containment and eradication methods

This species is notoriously difficult to control, much less eradicate. Only two successful eradications have been documented – both less than 25 hectares in size. Little fire ants were reportedly eradicated from Marchena Island in the Galapagos (Causton *et al.* 2005) and the island of Maui in the Hawaiian archipelago (Vanderwoude *et al.* 2010). In both cases, success was achieved using repeated application of baits laced with toxins. On Marchena, the infested zone consisted of low dry forest, and several applications of Amdro® a granular bait containing hydramethylnon (0.739 % a.i.) achieved eradication. In Hawai`i, infested areas consisted of lush tropical vegetation and little fire ants were nesting in tree canopies as well as on the ground. In this eradication, a combination of granular baits for the ground layer and a gel bait for vegetation were used. Treatments were applied eleven times over a 12 month period. The climate and vegetation on Tahiti resembled that of Maui more-so than Marchena. Therefore, containment and eradication procedures for Tahiti need to consider colonies nesting in vegetation.

Treatment Priorities

Financial constraints are likely to preclude any attempt at island-wide eradication. Therefore containment and site-eradication activities should target treatment of those sites that will yield the greatest benefit to Tahiti. The delimiting report for this project (see page 3) recommended treatment of high-value sites and reducing small infestations.

High-value sites

High value sites are those areas where little fire ants will have most social, economic or ecological impact as determined by the response agency. It is not possible for these sites to be prioritized in this report as these should be determined by Tahitian stakeholders. However, following are some suggested site types where impacts will be greatest.

Economic impacts

- Hotels, resorts, public use areas (beaches, tourist sites)
- Agriculture, tropical crops, food crops, nurseries, markets
- Commercial establishments that export goods inter-island or internationally

Social impacts

- Homes, hospitals, care facilities

Ecological impacts

- Natural areas (forests, beaches, rivers, cultural heritage sites)

Small developing populations

The future total area of infestation for Tahiti will be determined by a number of factors. These include the rate of natural growth of each infestation, the number of "jump-dispersal events" and the current number of infested areas. It is beyond the scope of this report to estimate rates of jump-dispersal; however, DIREN conducted an extensive survey and mapping of little fire ants on Tahiti Island in 2010. These data will be an under-representation of the true infested area. However, they provide the best available estimate of the distribution of this species as at 2010.

By applying a simple natural growth estimate of 20 metres per year for each infested site, growth in future years can be estimated. Figure 4 shows this growth according to the initial (2010) sizes of each infestation multiplied by the number of known infestations. Due to their larger number and quicker early growth relative to their original size, small developing infestations will be the major contributing factor to future growth. The total infested area of the 45 small (< 1 ha) sites recorded in 2010 was only 1.9 % of the total. However, these are predicted to comprise 28.5 % of the total infested area after 10 years (Table 2) .

These estimates suggest that more future benefit will be gained by reducing the current number of small infestations. Eradicating all infestations smaller than 1 hectare (15 ha total) will reduce future growth by 28.5%. In contrast, eradicating all current large (>50 hectare) infestations (526 ha) will provide a similar future result.

Table 2. Current and predicted (10 year) growth of little fire ant infestations on Tahiti by 2010 size classes and assuming a 20 metre annual rate of natural growth.

Initial size	current area (ha)	projected area (ha)	current % of total	projected % of total
<1 ha	15.0	794.4	1.9	28.5
1-5 ha	40.5	422.0	5.2	15.1
5.01-10 ha	39.1	201.2	5.0	7.2
10.01-20 ha	36.3	148.1	4.6	5.3
20.01-50 ha	125.5	333.9	16.0	12.0
> 50 ha	526.3	892.1	67.2	32.0
	782.8	2791.6	100.0	100.0

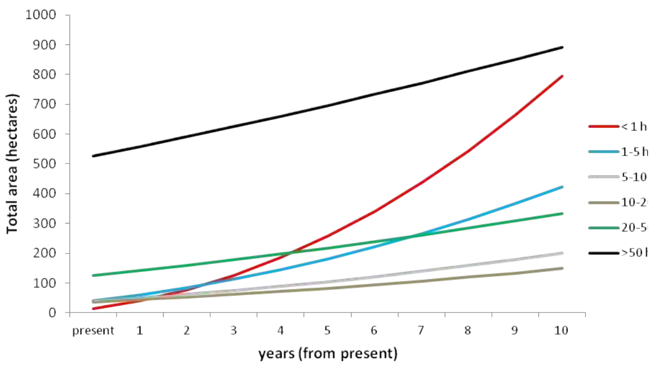


Figure 4. Projected growth of infested area (hectares) on Tahiti over ten years classed by 2010 infestation sizes and a 20 metre annual growth rate.

Treatment methods

Spot eradication

The current known little fire ant infestations on Tahiti can be considered as discrete "islands", each with its own independent treatment plan. Treatment and eradication of these islands can proceed independently from each other as resources permit. Although it is preferable for all sites to be treated immediately, this is not absolutely necessary.

On Maui, Vanderwoude *et al* (2010) demonstrated the use of a combination of treatments as an eradication strategy. The infestation was delimited by lure survey, a 20 metre buffer area was added and this comprised the treatment area. Granular baits were applied to the ground and a gel bait was used for colonies nesting in trees. These were applied monthly over 12 months. Standard operating procedures for both application methods are appended to this report.

Containment

The goal of containment is to limit or prevent further spread of a pest. For containment, only the edge of an infested area needs to be treated as little fire ants do not disperse by flight. Once an infested site has been carefully delimited and a 20 metre buffer applied to the edge of the infestation, the site can be contained through use of a residual pesticide applied in a 2-4 metre band to the ground and vegetation. Alternatively, granular baits can be applied in a band if there is a clear vegetation-free separation between uninfested and infested land. Standard operating procedures for both application methods are appended to this report.

Suggestions for targeted monitoring

When eradication of a new pest is not possible or feasible, targeted mitigation efforts can reduce impacts and spread. Monitoring the spread of a new pest species can greatly assist decision makers in allocating limited resources to this activity by and target priority areas. Monitoring for this species should focus on three key areas; spread pathways and associated vectors, high-value sites and the prevention of spread to neighbouring islands and international destinations.

Pathways and vectors

Any item being transported by humans can potentially harbour little fire ants. However, some items are more likely to vector this species than other. Monitoring for little fire ants should focus primarily on pathways for the movement of the following items:

- Potted plants
- Foliage, lays, cut flowers, orchids
- Banana suckers, bamboo cuttings, palms
- Soil, items stored in contact with soil
- Soil, mulch, trash, green waste, plant trimmings
- Agricultural produce – taro, pineapple, papaya, avocado, lychee, yam and others
- Vehicles, especially those with unclean truck beds and undersides

High value sites

High value sites are those areas where little fire ants will have most social, economic or ecological impact as determined by the response agency. It is not possible for these sites to be prioritized in this report, however, the following are some suggested site types where impacts will be greatest.

Economic impacts

- Hotels, resorts, public use areas (beaches, tourist sites)

- Agriculture, tropical crops, food crops, nurseries, markets
- Commercial establishments that export goods inter-island or internationally

Social impacts

- Homes, hospitals, care facilities

Ecological impacts

- Natural areas (forests, beaches, rivers, cultural heritage sites)

Prevention of inter-island and international spread

French Polynesia is comprised of approximately 130 islands in six island groups. Transportation of people and commodities to neighbouring islands is primarily via Tahiti, by boat or ship from the port of Papeete. Few neighbouring islands have air strips that are used on a regular basis, and the majority of commodities are transported by boat.

Preventing the spread of little fire ants to neighbouring islands should be a major focus of any response plan for French Polynesia. Risk items are treated by methyl bromide fumigation at the Ministry of Agriculture facility. However, this practice is voluntary and not mandatory. Regular monitoring for little fire ants should be conducted for the domestic port area, cargo holding facilities, cargo, and for the personal possessions of travellers.

French Polynesia has few export commodities. The majority of foreign capital is derived from two main sources; the tourist industry, and the sale of marine-derived items including seafood and pearls. Tourists are potential vectors for the outward movement of little fire ants, especially via possessions that may have been in contact with soil; tents and other camping equipment, hiking equipment, as well as through the purchase of handicrafts at markets and souvenir stores. The major export commodities of seafood and pearls are unlikely to harbour little fire ants. However, a substantial portion of waste products (e.g. steel and aluminium for recycling) are sold to overseas markets including New Zealand and Asia. These have a greater potential for contamination.

Regular monitoring for little fire ants should be conducted for the international sea port and airport areas, cargo holding facilities, cargo, and personal possessions of travellers. Also, regular monitoring of waste transfer and processing facilities should be conducted.

Monitoring Methodologies

There are many different monitoring methods for detecting the presence and relative abundance of little fire ants. Each method has advantages and disadvantages, depending on the purpose of the survey. While it is difficult to assign a numeric estimate of confidence in any method, the main methods currently used are described below. Below are descriptions of the main methods in use today. Standard operating procedures for each method are found in the appendices.

Visual searching

Operators trained in visual searching methods and field identification of little fire ants are able to quickly cover relatively large areas in detection surveys. Searchers visually check preferred nesting sites and foraging areas that are present on the site. This method is suitable for detecting well-established colonies of little fire ants. However, it requires that searchers have a higher level of training and knowledge than other methods. It is not a method suitable for detecting small or incipient colonies. However, it is a good method for inspecting commodities such as potted plants and produce.

Lure surveys

Although little fire ants are primarily sugar feeders, they are consistently attracted to sources of lipids (fats) and proteins in their environment. An unconfirmed theory for this is that both lipids and proteins are limiting factors in colony development and often not available in sufficient quantities. Peanut butter is an attractive source of both protein and lipid to which little fire ants recruit readily. Placing small amounts on a carrier such as a vial, Popsicle stick or similar allows lures to be deployed systematically across a site. After a suitable exposure time these can be retrieved and examined for presence of the target species. Identification can be conducted in the field by trained searchers, or any suspect samples can be returned to a laboratory for further identification by an ant specialist.

This method has several clear advantages. Searchers require a minimal level of training, the method is systematic and results are broadly comparable with surveys conducted elsewhere. Results can also be used to provide estimates of the severity of infestation by counting individual ants at each lure or bait.

Intercept surveys

Standard sampling methods for ground-active invertebrates include intercept methods such as pitfall traps and sticky traps. A pitfall trap is comprised of a small vial or container buried in the ground with the top edge level with the soil surface. A small amount of preservative such as ethanol, soapy water or ethylene glycol is added to the vial and the trap is left open for days or even weeks. Crawling invertebrates such as ants accidentally fall into a trap of this type. Once retrieved, any insects can be identified by a trained ant specialist. Sticky traps work in a similar fashion. These are cards with an adhesive surface which are placed in locations where ants are likely to forage. After a suitable exposure time, the cards are retrieved and any insects caught by the adhesive surface can be identified.

Intercept traps usually have a longer exposure time than lures, and therefore will capture more insects. They have the advantage of being less dependent on variables such as time of day and temperature, and are therefore more likely to detect incipient colonies that have small numbers of foraging workers. However, they are time-consuming to deploy and require at least two visits to the site. While more accurate, they are more costly in terms of time and travel.

Passive detection methods

The methods described previously are "active" methods and require operators to visit a site and conduct a survey. It is not economically possible or feasible to survey every site on Tahiti, so general survey and monitoring activities should target sites with the greatest probability of infestation. Passive methods do not require site visits and rely on the cooperation of the public or selected industries. Engaging the public or selected groups of people is often termed "public outreach". Activities that increase awareness of the little fire ant problem, especially if they encourage residents to contact an appropriate department through a dedicated phone number, often result in detections of previously unknown infestations. Aside from general public awareness activities, several key groups should be targeted:

- Nursery and landscape industries – these industries are primary vectors for spread of this species
- Garden clubs and market vendors – people engaged in these activities are often in close contact with garden plants and other vectors.
- Waste management workers – residential waste can become infested by little fire ants, and informed waste collectors may notice this and report new infestations.
- Tree trimmers and landscaping contractors – operators working in this industry are likely to experience little fire ant stings as they visit sites to conduct their business
- Veterinarians – little fire ants stings can cause tropical keratopathy or "Florida Spots". While this condition is not caused exclusively by little fire ants, follow-up of any new cases may result in discovery of new infestations.

Recommendations

Spot eradication of small infested sites

The survey conducted by DIREN in 2010 identified 86 infested sites with a total area of 780 hectares. Over half of these sites are smaller than 1 hectare and 80 % less than 5 hectares. These sites make up 1.9 % and 5.2 % of total infested land, but will grow disproportionally over the next 10 years to comprise 43.6 % of total infested area (excluding new infestations). Eradicating these smaller infestations will require treatment of 55.5 hectares but reduce future infested area by 1,216 hectares (assuming 20 metre annual growth). Treatments should comprise of a combination of granular baits applied to the ground and gel baits applied to vegetation.

Recommendation 1: Eradication efforts should focus on eliminating small (<1 hectare) infestations and if resources permit, infestations sized 1-5 hectares.

Containment of larger infested sites

Larger sites will grow at a relatively slower natural rate than smaller infestations. Containment efforts should focus on these larger >5 hectare infested sites. The goal for containment is to reduce the rate of natural spread in a cost effective manner. Regular treatment of the edges of these infestations, either with a residual pesticide or granular baits is the most efficient approach.

Recommendation 2: Containment activities should focus on larger (>5 hectare) infested sites.

Estimating the rate of natural spread

The rate that little fire ant colonies spread, once established, is an unknown factor. Knowledge of this factor will increase the accuracy of any growth estimates, and will greatly assist decision makers.

Recommendation 3: Further research is needed to quantify the rates of spread for little fire ants on Tahiti.

Monitoring pathways and vectors

Jump dispersal, or the accidental re-location of little fire ant colonies is a major factor in the local spread of little fire ants, the, the pathways and vectors are well known from experience in other infested locations in the Pacific region.

Recommendation 4: Known pathways and vectors for spread of little fire ants on Tahiti should be monitored and risk minimization efforts should target these pathways.

Minimizing transfer to neighbour islands within French Polynesia

Currently only two (Tahiti and Moorea) of the 130 or so islands that make up French Polynesia have little fire ants. Domestic quarantine activities (monitoring and inspection of risk items) will greatly reduce the risk of spread to neighbouring islands.

Recommendation 5: Resources should be allocated to enhanced domestic quarantine inspections for risk items being transported to neighbour islands.

Recommendation 6: Domestic points of departure, especially the sea port and cargo handling facilities should be surveyed frequently to ensure these sites are free of little fire ants

Minimizing international transfer

Although French Polynesia exports relatively few commodities with risk of infestation, these should be monitored to minimize risks of spread to other countries.

Recommendation 7: International points of departure, especially the sea port, airport and cargo handling facilities should be surveyed frequently to ensure these sites are free of little fire ants

Recommendation 8: Resources should be made available for enhanced international out-bound quarantine activities to monitor and inspect cargo, personal possessions and empty shipping containers bound for international destinations.

Outreach as a component of monitoring activities

Outreach is a vital component of any pest management strategy. A good outreach strategy targeting residents, visitors and key industries can greatly assist in identifying new infestations and reduce the risks associated with the movement of known vectors.

Recommendation 9: Resources should be allocated to the development and implementation of a targeted outreach strategy designed to identify new infestations and reduce the risks associated with known little fire ant vectors.

References

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Chapter 4: Extension of the biosecurity monitoring Programme in French Polynesia and its trading partners, with a focus on the little fire ant

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Summary

Little fire ants (*Wasmannia auropunctata*) are an established and expanding invasive pest in French Polynesia. This species poses a serious threat to the economy, ecological health and social well-being of this country and its inhabitants. As little fire ants spread, the impact will become more severe leading to an urgent need for action on the part of authorities. Additionally, the presence of little fire ants poses a biosecurity threat to countries receiving goods from French Polynesia, potentially causing rejection of commodities and additional export costs for shippers.

Two islands, Tahiti and Moorea, are infested with little fire ants with the remaining 130 or so French Polynesian islands currently free of this pest. However, without a comprehensive management strategy, this species will spread throughout the country in future years, most likely infesting a majority of inhabited islands. Proactive planning has now will have the best potential to minimize these impacts and ensure resources are used in the most efficient and effective manner.

This report provides an overview of current biosecurity practices and discusses options for strengthening domestic and international biosecurity systems. The specific topics addressed are:

- An analysis of French Polynesia's main trading partners in the Pacific region
- A description of current biosecurity practices of French Polynesia's main trading partners
- A description of inter-island and international biosecurity practices in French Polynesia
- A discussion of methods to strengthen biosecurity systems for invasive ants
- Recommendations and cost estimates for implementation.
- The development of standard operating procedures for monitoring, surveillance and response activities
- The following actions are recommended to address the growing impacts of little fire ants:
- Development of an early detection program which includes regular and systematic surveillance of international points of entry for travelers and commodities, including increased power of search for French Polynesian quarantine officers.
- Development of a national emergency response plan for invasive ants.
- Establishment of a biosecurity strategy that minimizes the inter-island spread of little fire ants. This should include:
- Mandatory fumigation of high-risk commodities before movement to other islands
- Enhanced quarantine inspection of travelers and their possessions to neighboring islands and their possessions
- Increased public awareness and outreach on the risks and impacts of invasive ants.
- Develop and implement an eradication program for known infestations on Moorea.

- Identify the distribution of "secondary" invasive ant species for the main islands of within French Polynesia.
- Develop and implement a mitigation strategy for little fire ants on the island of Tahiti
- Focus eradication efforts on eliminating small (<1 hectare) infestations and if resources permit, infestations sized 1-5 hectares.
- Attempt to contain larger (>5 hectare) infested sites.
- Conduct research to quantify the rates of spread for little fire ants on Tahiti.
- Monitor known pathways and vectors for spread of little fire ants within Tahiti.
- Develop and implement a targeted outreach strategy designed to identify new infestations and reduce the risks associated with known little fire ant vectors.
- Assist affected residents by providing practical extension advice on how to manage ant populations.
- The Service du Developpement Rural should formally approach the quarantine agencies of New Zealand and Australia in order to develop off-shore hygiene partnerships between themselves and relevant industry partners.
- Options for increased out-bound biosecurity inspections of shipments of household goods be explored by Service du Developpement Rural management.
- A full-time team of at least four specialist staff dedicated to the coordination and implementation of these recommendations should be established within the Service du Developpement Rural, liaising closely with the quarantine service of that agency. Additional external support may be needed to develop a national emergency response plan, form an eradication plan for Moorea, provide training for surveillance, treatment and other specialized activities, and the conduct of applied research on basic biology and efficacy studies for control products.

Background

Little fire ants (*Wasmannia auropunctata*) are an established and expanding invasive pest in French Polynesia. This species poses a serious threat to the economy, ecological health and social well-being of French Polynesia and its inhabitants. Once established, little fire ants form dense three-dimensional super colonies that cover the ground, vegetation and tree canopies. Ants nesting in trees are easily dislodged by wind and other minor disturbances and often fall from their arboreal homes onto people and animals below, stinging their victims and causing blindness in domestic animals. In natural ecosystems, they prey on, or drive out native fauna, leaving an ecosystem depleted of much of its pre-existing animal life. The mutualisms formed between little fire ants and Homoptera cause crop losses in agriculture and declines in plant health for native ecosystems. The presence of little fire ants poses a biosecurity threat to countries receiving goods from French Polynesia, potentially causing rejection of commodities and additional export costs for shippers.

Two islands, Tahiti and Moorea, are infested with little fire ants. Tahiti is the most populated of the 130 or so islands that make up French Polynesia and ten of its 13 municipalities are infested to varying degrees. Almost all cargo entering and leaving the country is shipped to and from the port of Papeete. This species will spread throughout the country in future years, most likely infesting a majority of inhabited islands.

Report scope

This report is one of several reports prepared for this project. One report (Vanderwoude, 2013a) details the current extent of little fire ant distribution in French Polynesia. A second report (Vanderwoude, 2013b) provides a basis for a monitoring and mitigation strategy for the island of Tahiti and neighbouring islands. This report aims to provide an overview of current biosecurity practices and discusses options for strengthening domestic and international biosecurity system. The specific topics addressed are:

- An analysis of French Polynesia's main trading partners in the Pacific region.
- A description of current biosecurity practices of French Polynesia's main trading partners.
- A description of inter-island and international biosecurity practices in French Polynesia.
- Discussion of methods to strengthen biosecurity systems for invasive ants.
- Recommendations and cost estimates for implementation.
- Development of standard operating procedures for monitoring, surveillance and response activities.

French Polynesia trading partners

The majority of goods and other cargo moving between countries in the Pacific region and French Polynesia are sourced from, or destined for, New Zealand, Australia, New Caledonia, Wallis & Futuna, the Cook Islands and Fiji.

Trade data for French Polynesia were obtained from the United Nations Commodity Trade Statistics Database (http://comtrade.un.org/db/) for the 2012 reporting year. The total value of all exports to Pacific countries and Australia were USD6.6 million and the total value of imports was USD 218.9 million (Table 1). This comprised 4.2% of total exports and 11.9% of total imports for French Polynesia.

The four main Pacific destinations for exports were New Caledonia (45.9%), New Zealand (25.78%), Australia (16.97%) and Wallis and& Futuna (7.1%). Imported commodities were almost entirely sourced from New Zealand (65.6%) and Australia (31.4%).

Table 1. Summary of global trade for French Polynesia and the rest of the world for 2012 (data in US$, sourced from United Nations community trade statistics databases).

Trading partner	Exports	% (Pacific)	Imports	% Pacific
New Caledonia	$3,014,032.00	45.90	$1,165,133.00	0.53
New Zealand	$1,692,648.00	25.78	$143,734,662.00	65.65
Australia	$1,107,811.00	16.87	$68,800,158.00	31.43
Wallis & Futuna	$462,776.00	7.05	-	0.00
Cook Islds	$180,263.00	2.75	-	0.00
Fiji	$84,456.00	1.29	$4,888,066.00	2.23
Tonga	$9,262.00	.14	$179.00	0.00
Vanuatu	$8,331.00	0.13	$65.00	0.00
Samoa	$7,376.00	0.11	$63,860.00	0.03
PNG	-		$273,327.00	0.12
Guam	-		$2,883.00	
Solomon Islds			$782.00	
Pacific region (total)	$6,566,955.00		$218,929,085.00	
Rest of the World	$143,250,906.00		$1,408,797,872.00	
TOTAL	156,384,816.00		1,846,656,042.00	

Many Pacific countries including French Polynesia are net importers of commodities. Total exports to the Pacific region are extremely low, amounting to less than USD7 million. The risks posed by commodities leaving French Polynesia are therefore proportionally low. Additionally, most export commodities are unlikely to harbour little fire ants. For example, over half of exports were natural and cultured pearls (Table 2)

Table 2. Main commodities exported from French Polynesia during 2012 categorized by international "Harmonized Tariff" codes (data sourced from United Nations community trade statistics database).

HS code	Description	Per cent total
7101	Pearls, natural or cultured	54.8
0302	Fish, fresh or chilled	6.9
1513	Coconut, palm kernel or babassu oil	5.5
2007	Jams, fruit jellies, marmalades, fruit or nut pastes	3.9
0304	Fish fillets and other fish meat	2.8
0508	Coral and similar materials, unworked or simply prepared	2.1
0905	Vanilla	1.7
8802	Other aircraft	0.4
8411	Turbo-jets, turbo-propellers and other gas turbines	0.3

Of the four main trading partners, New Caledonia (Fabres and Brown jnr 1978) and Wallis and Futuna (Jourdan 1997) are already infested with little fire ants. Australia also has little fire ants, however, distribution is limited to the Cairns area and this population is under active suppression (www2). Movement of infested commodities to New Caledonia and Wallis and &Futuna, poses a low risk as little fire ants are already present in those countries. Therefore, in terms of export risks within the Pacific region, Australia and New Zealand are at the greatest risk.

The remaining Pacific destinations with any significant imports from French Polynesia are the Cook Islands (2.75%) and Fiji (1.29%). Although total exports to these countries combined have a total value less than USD $300,000, these exports do carry a biosecurity risk.

Other biosecurity risks related to trade

Invasive ants, including little fire ants are categorized as "hitch-hiker" pests. Their presence is not related to the commodity being transported. Any cargo can potentially carry hitch-hiker pests and this confounds commodity-based risk assessment techniques used by most biosecurity agencies.

The majority of commodities are transported by ship, packed in steel shipping containers. An imbalance between imports and exports leads to a surplus of these shipping containers in locations that export less products that they receive. In the case of French Polynesia, there is a trade imbalance of 33:1 for movement of goods to and from countries in the Pacific region. For shipping lines, this means empty containers need to be returned to the exporting country, and 97% of shipping containers leave French Polynesia empty.

Although empty shipping containers do not carry commodities, they can, and do, harbor invasive species and other contaminants. Often, shipping containers are transported to the importer's (consignee) premises, unpacked, and left for long periods of time at these premises before being returned to the ports. During this time, invasive species, including ants, can colonize these containers and be transported to new locations. Biosecurity authorities in New Zealand and Australia have recognized this pathway as a major biosecurity concern. (see Nendick 2006). As a result, empty shipping containers being returned to these countries are also subjected to biosecurity inspections.

Biosecurity risks associated with cargo are often determined by the commodity being transported. For example, a shipment of a particular agricultural product could trigger a search for pests and diseases specific to that product. The movement of personal belongings (household goods) from one country to another can potentially escape this biosecurity profiling. The long-term relocation of people and their personal possessions to and from French Polynesia is likely to reflect its cultural/political ties to France and the economic relationships with Australia and New Zealand. It is likely that there would be an exchange of business personnel between major trading partners and regular relocation of civil servants between French administrations within the Pacific region. The movement of personal possessions therefore comprises part of the total biosecurity risk for little fire ants between these countries.

Biosecurity practices of major trading partners

The two major trading partners for French Polynesia are Australia and New Zealand. These countries both have robust biosecurity systems that are broadly held as "International Best Practice" benchmarks by other jurisdictions.

New Zealand

The New Zealand Ministry for Primary Industries implements its biosecurity system through a sub-agency named Biosecurity New Zealand. New Zealand has a robust biosecurity system which includes a specific focus on trade within the Pacific region (see www3). The focus on biosecurity within the Pacific region includes active collaboration with trading partners, providing opportunities for assistance and training, off-shore risk management and active participation in regional initiatives such as the Pacific Ant Prevention Plan (IUCN/SSC Invasive Species Specialist Group 2004).

One such initiative has been the development of off-shore risk reduction strategies which include formal hygiene programs for New Zealand -bBound cargo and empty shipping containers at ports of origin. New Zealand biosecurity agencies conduct both species-based, commodity-based and country-based risk assessments to target biosecurity activities.

Biosecurity New Zealand is very active in the Pacific region, especially in relation to the spread of invasive ants. In recent years it has been involved in several projects to strengthen the region's capacity for detection and response to this issue. Some of the activities French Polynesian biosecurity staff have participated in include:

- In-country training for invasive ant surveys at points of entry for Tahiti
- Development of a generic emergency response plan for invasive ants
- Provision of advanced taxonomic training to increase diagnostic capacity

Australia

The Australian Department of Agriculture, Forestry and Fisheries (DAFF) implements Australia's biosecurity program. Until recently this task was undertaken by the Australia Quarantine Inspection Service (AQIS), however, this agency is currently being restructured. Additionally, the Quarantine Act (1908) is in the process of being replaced with new quarantine legislation. Australia's biosecurity system. Australia's biosecurity threat assessments include species, commodity and country-based risk assessments.

In addition to an active biosecurity system, the Australian Department of Sustainability Environment, Water, Population and Communities has prepared a number of threat abatement plans for potential and existing invasive species. One of these plans focuses on invasive ants (Commonwealth of Australia 2006).

New Caledonia, Wallis and Futuna

Smaller Pacific Nnations appear to be mostly influenced by restrictions placed on their exports by their trading partners. In-bound biosecurity systems are often limited by available resources and low funding levels. Almost all Ppacific Nnations are members of the Secretariat of the Pacific Community (SPC). The Land Resources division of SPC assists and coordinates biosecurity activities, policy, training and knowledge exchange for participating member countries which includes French Polynesia through its biosecurity and trade section. This division section also administers a regional policy and information exchange body, the Pacific Plant Protection Organization which is a regional policy and information exchange body.

Biosecurity practices in French Polynesia

International biosecurity

Traditionally, the biosecurity strategy of a given country is entirely focused on incoming goods, giving with little attention or mandate for out-bound biosecurity. A notable exception to this is the Brown Tree Snake detection activities conducted in Guam. Here the United States Department of Agriculture, through the Animal and Plant Health Inspection Service, conduct an extensive inspection and removal program of this species for outbound cargo and vessels.

For French Polynesia, the national biosecurity program is focused on preventing entry of new pests and diseases. "Out-bound" biosecurity activities are the responsibility of individual exporters and are usually prescribed by agencies in receiving countries. As an example, recyclable waste such as scrap steel and aluminium are exported to several countries including New Zealand. These products are treated in accordance with prescribed "Import Health Standards" determined by Biosecurity New Zealand which include treatment of the commodity with pesticides.

One notable weakness of the biosecurity program of French Polynesia is the lack of legislation to support legislative lack of the power of search for quarantine officers inspecting inbound baggage and mail items. This absence of this power prevents quarantine officers from opening, searching or even inspection via x-ray scanners of any suspect incoming items. This power is only vested in customs officers. As a result, only incidental discoveries during the course of inspections by customs officers are ever likely to be passed onto quarantine staff for further assessment.

Inter-island biosecurity

French Polynesia has an extensive and sophisticated internal biosecurity program administered through its Agriculture Department, Service du Developpement Rural. The backbone of this system is the provision of free fumigation services for any commodities at risk of vectoring plant or animal pests. The Service du Developpement Rural manages a fumigation facility adjacent to the main shipping port of Papeete. This consists of fumigation chambers which use methyl bromide fumigant – a highly effective quarantine treatment for both plant and animal pests. It is staffed by well-trained trained operators and complies with international quarantine standards.

However, this service is not mandatory and relies on voluntary compliance by travellers, who may choose not to make use of it. In addition there are no systematic inspections of inter-island travellers or their personal possessions.

Recommendations on actions to improve biosecurity with a focus on spread of invasive ants

French Polynesia faces several distinct threats from the entry and spread of invasive ants:

- Entry of invasive ant species not already present in the country,
- Spread of existing invasive ant species (eg., *Wasmannia auropunctata*) between the 130 or so islands that make up the archipelago,
- Spread of existing species (eg., *Wasmannia auropunctata*) within the municipalities of Tahiti.

Becoming a vector for the spread of *Wasmannia auropunctata* within the Pacific Region.

Entry of new species of invasive ants

Most common tramp ant species are already present in French Polynesia. These include:

1. *Pheidole megacephala* – big-headed ant
2. *Solenopsis geminata* – tropical fire ant
3. *Monomorium destructor* – Singapore ant
4. *Anoplolepis gracilipes* – yellow crazy ant
5. *Paratrechina longicornis* – brown crazy ant
6. *Technomyrmex albipes* – white-footed ant

- *Tapinomamelano cephalum* – ghost ant
- *Wasmannia auropunctata* – little fire ant

With the exception of the little fire ant, these species have a broad pan-Pacific distribution and in some cases, a worldwide distribution. They are species very common throughout the Pacific region. Although these species do have some economic, social and ecological impacts, they pale into insignificance when compared with the little fire ant. Invasive ants not present here, and with known major impacts include the red imported fire ant (*Solenopsis invicta*), the tawny crazy ant (*Nylanderia fulvus*) and the Argentine ant (*Limepithema humile*).

The strategy to exclude or minimize the risk of the entry of invasive ants must therefore focus on these three species. Early detection and response is the recommended strategy for addressing risks from invasive species and this requires two important and inter-connected programs:

1. An early detection system coupled with country-specific risk analyses for red imported fire ants, tawny crazy ants and Argentine ants.
2. Addition of the power to search for French Polynesian quarantine officers, either through legislative change ex officio powers for appointed officers under customs legislation, or increased level of cooperation and involvement of customs officers.

A viable emergency response plan to address any incursions that are detected.

The following actions are recommended:

Recommendation 1: Development of an early detection program which includes regular and systematic surveillance of international points of entry for travellers and commodities, including increased power of search for French Polynesian quarantine officers.

Recommendation 2: Development of a national emergency response plan for invasive ants.

Mitigating the spread of existing invasive ant species (*Wasmannia auropunctata*) between the islands of French Polynesia

The main species of concern is the little fire ant. However, little is known about the distribution of other common invasive ant species within the islands of French Polynesia. Little fire ants are restricted to the islands of Tahiti and Moorea. On Moorea, only two small infestations have been recorded. Preventing further spread of this species, and attempting the eradication of little fire ants from Moorea should be the highest mitigation priority. A second priority should be to identify the distribution of invasive ants of secondary importance for each main island. The following actions are recommended to address this threat:

Recommendation 3: Establishment of a biosecurity strategy that minimizes the inter-island spread of little fire ants. This should include:

- Mandatory fumigation of high-risk commodities before movement to other islands
- Enhanced quarantine inspection of travelers to neighboring islands and their possessions
- Increased public awareness and outreach on the risks and impacts of invasive ants.

Recommendation 4: Develop and implement an eradication program for known infestations on Moorea.

Recommendation 5: Identify the distribution of "secondary" invasive ant species for the main islands within French Polynesia.

Limit the spread of little fire ants within Tahiti

As little fire ants spread throughout Tahiti, impacts to the economy, people and the environment will become more severe. Additionally, the risk of transfer to other islands within French Polynesia and the Pacific region will increase in direct proportion to the degree of infestation. The topic of mitigating impacts for Tahiti are covered in a separate report and recommendations included:

- Eradication efforts should focus on eliminating small (<1 hectare) infestations and if resources permit, infestations sized 1-5 hectares.
- Containment activities should focus on larger (>5 hectare) infested sites.
- Further research is needed to quantify the rates of spread for little fire ants on Tahiti.
- Known pathways and vectors for the spread of little fire ants on Tahiti should be monitored and risk minimization efforts should target these pathways.
- Resources should be allocated to enhanced domestic quarantine inspections for risk items being transported to neighboring islands.
- Domestic points of departure, especially the sea port and cargo handling facilities should be surveyed frequently to ensure these sites are free of little fire ants
- International points of departure, especially the sea port, airport and cargo handling facilities should be surveyed frequently to ensure these sites are free of little fire ants
- Resources should be made available for enhanced international out-bound quarantine activities to monitor and inspect cargo, personal possessions and empty shipping containers bound for international destinations.
- Resources should be allocated to the development and implementation of a targeted outreach strategy designed to identify new infestations and reduce the risks associated with known little fire ant vectors.

Recommendation 6: Develop and implement a mitigation strategy for little fire ants on the island of Tahiti

Reducing the spread of little fire ants within the Pacific region and Australia

Biosecurity agencies are rarely mandated to maintain "outbound" biosecurity programs as it is the responsibility of receiving jurisdictions to protect their own borders. However, French Polynesia could consider extending its biosecurity mandate to include such activities. The two most important pathways for the international spread of little fire ants from French Polynesia are through the return of empty shipping containers and the transport of shipments of household goods for people moving between countries within the Pacific region.

One way to reduce the risks associated with shipping containers would be to participate and regulate off-shore risk reduction programs. This would involve a collaboration between exporting businesses, port authorities, shipping companies and the biosecurity agencies of trading partners. Both Australian and New Zealand agencies are likely to be very receptive to these concepts. The majority of compliance costs would be borne by private businesses however, the returns in lower compliance costs are likely to off-set and even exceed program costs.

The government of French Polynesia could consider implementing additional procedures and inspections for household items being shipped between Tahiti and other Pacific countries. This activity is not currently within the charter of the Service du Developpement Rural and may require legislative and resourcing changes in order for it to be implemented.

Recommendation 7: The Service du Developpement Rural formally approach quarantine agencies of New Zealand and Australia in order to develop off-shore hygiene partnerships between themselves and relevant industry partners.

Recommendation 8: Options for increased out-bound biosecurity inspections of shipments of household goods be explored by Service du Developpement Rural management.

Prioritized recommendations and cost estimates

It is a difficult task to prioritize the recommendations outlined in this report. Priorities will differ for many stakeholder groups, especially when the movement of little fire ants from French Polynesia to other jurisdictions is considered. Recommendations to reduce the risk of entry and spread of invasive ants and to minimize their impact on s to the economy, people and environment of French Polynesia are listed below in three categories: high, moderate and low priority. These priorities are based on the benefits expected for French Polynesia. An attempt at providing estimates of the costs associated with their implementation are included.

High priority recommendations

Recommendation 3: Establishment of a biosecurity strategy to minimize inter-island spread of little fire ants

The nation of French Polynesia is comprised of approximately 130 separate islands known worldwide for their extraordinary natural beauty. A large proportion of the country's inward currency flow is driven by tourism, and one main tourist draw-cards is the unspoiled nature of the islands. The spread of little fire ants throughout French Polynesia threatens both environmental values and economic prosperity.

Preventing the spread of little fire ants to uninfested islands should therefore be one a high priority goal. A biosecurity strategy to achieve this will require resources including:

- Planning and development of a quarantine strategy
- Between two and four additional Service du Developpement Rural inspection officers and/or trained detector dogs
- Additional supplies of methyl bromide and fumigation operators

Recommendation 4: Develop and implement an eradication program for known infestations on Moorea.

There are only two known infestations on the island of Moorea: one approximately 0.5 hectare and one approximately 5 hectares in size. Untreated, these will invariably spread to the rest of Moorea, with impacts and economic costs consistent with the total infested area. It is technically feasible to eradicate these infestations. The benefit-to- cost ratio of such a project is likely to be high.

The following resources are needed to achieve this:

- A commitment to long-term funding of the project (at least six years)
- Development of an eradication plan based on world best practice. This plan should include provision for at least three years post-eradication monitoring to ensure pest-free status. The Plan development of a plan will require extensive input from scientific personnel and operational managers.
- Allocation of human resources, chemicals and other materials necessary to implement the plan
- Training of operatives in treatment methods, data collection and surveillance.

Recommendation 6: Develop and implement a mitigation strategy for little fire ants on the island of Tahiti

The continued spread of little fire ants within Tahiti is inevitable, and an attempt at eradication is unlikely to succeed without a substantial economic investment. However, both the impacts and the spread can be minimized by a targeted approach. Recommendations for developing this strategy is outlined in more detail in another report and are summarized below:

- Focus eradication efforts on eliminating small (<1 hectare) infestations and if resources permit, infestations sized 1-5 hectares.
- Attempt to contain larger (>5 hectare) infested sites.
- Conduct research to quantify the rates of spread for little fire ants on Tahiti.
- Monitor known pathways and vectors for spread of little fire ants within Tahiti.
- Develop and implement a targeted outreach strategy designed to identify new infestations and reduce the risks associated with known little ire Ant vectors.
- Assist affected residents by providing practical extension advice on how to manage ant populations.

Moderate priority recommendations

Recommendation 1: Development of an early detection program which includes regular and systematic surveillance of international points of entry for travellers and commodities, including increased increasing the power of search for French Polynesian quarantine officers.

An early detection programme should be implemented to prevent entry and spread of new invasive ant species. This will require regular (4 times per year) surveys at all international points of entry by trained surveillance staff and provision of taxonomic and data management support. Resources needed include:

- Survey staff (approximately 180 person-days),
- Taxonomic support (90 person-days)
- Data management staff (30-60 person- days)
- Provision of training for survey staff, possibly taxonomic staff.
- Survey materials, microscope, GPS units, computer, vehicle

Recommendation 2: Development of a national emergency response plan for invasive ants.

A well-developed emergency response plan for invasive ants will ensure any new incursions are managed efficiently and effectively. Such a plan should be developed by a contractor in collaboration with key personnel from relevant agencies.

Recommendation 3: The Service du Developpement Rural formally approach quarantine agencies of New Zealand and Australia in order to develop off-shore hygiene partnerships between themselves and relevant industry partners.

The cost of biosecurity inspections and treatment for goods arriving in Australia and New Zealand are borne directly by the shipping lines (empty containers) and shipping agents (commodities). The operational cost of off-shore hygiene programs are normally paid for by the users and are potentially off-set by lower inspection and treatment costs. Active endorsement and collaboration by quarantine agencies therefore have few costs, but do require some staff time for oversight and audit tasks.

Recommendation 4: Options for increased out-bound biosecurity inspections of shipments of household goods be explored by Service du Developpement Rural management.

Outbound inspections for biosecurity purposes are not normally within the mandate of biosecurity agencies. Implementation of such a programme will require allocation of additional inspection staff.

Low priority recommendations

Recommendation 5: Identify the distribution of "secondary" invasive ant species for main islands within French Polynesia.

A comprehensive island survey to identify which species are present and absent on each island within French Polynesia will support efforts to limit the spread of invasive ant species within the archipelago. The probable impacts of these "secondary" ant species is likely to be substantially less than those for little fire ants and therefore of lower priority.

Suggestions for implementation and cost estimates

The Hawaiian archipelago has a similar history of invasion by little fire ants, however, the invasion there has been present longer. As little fire ants spread within Hawai'i, the resources needed to manage impacts have increased steadily. Currently, there are four people employed on a full-time basis to coordinate mitigation, eradication, outreach and extension activities. French Polynesia is likely to need similar resources.

Most high and moderate priority recommendations in this report could be addressed by a combination of the following:

- The formation of a dedicated team of 4 staff (with supplementary field support), managed from within the Service du Developpement Rural agency.
- Additional input and resourcing from the biosecurity section within the Service. This may require hiring of additional staff, especially inspectors. Trained detector dogs should be considered as an inspection tool.

External needs include expert assistance with:

- Development of an emergency response plan,
- Formation of an eradication plan for Moorea,
- Training for surveillance, treatment and other specialized activities, and.
- Conduct of applied research on basic biology and efficacy studies for control products.

Conformance with the Pacific Ant Prevention Plan (PAPP)

The recommendations in this report are closely aligned with the objectives of the Pacific Ant Prevention Plan which is a regional strategy document that supports a coordinated approach to the issue of invasive ants in the Pacific region. It recommends:

- Appropriate legislation, regulations or standards to deal with invasive ants pre-border and at the border;
- Risk analysis that covers the region but which can be adapted for implementation to each country or territory;
- Regional trade agreements which accommodate risks associated with invasive ants;
- Operational measures which can be applied to each territory and will actually prevent ants gaining entry;
- A range of surveillance measures appropriate to quickly identify the presence of a new invasive ant in each territory;
- Appropriate incursion response procedures and the capability to enact them;
- A regional public awareness strategy to ensure the ant species concerned have appropriate public profiles so the risks of their establishment are well understood by sections of the community; and

- An active research programme to ensure the measures used to prevent establishment have a sound scientific base and thus will have the greatest likelihood of success.

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www3 Biosecurity New Zealand Pacific Activities Advisory Group http://www.biosecurity.govt.nz/biosec/pacific-portal (page accessed 26 July 2013)

Chapter 5: Biodiversity protection and invasive species management legislation

Jerry Biret

In French Polynesia, examining an issue from a regulatory perspective often amounts to studying the division of powers between authorities, given the country's statutory jurisdiction. This makes it difficult, particularly for a novice, to understand all the nuances of the on-the-ground implementation of the rules. Legal implementation aside, practical implementation can be difficult given the limits imposed by statutory law and, more importantly, those imposed by the geography of French Polynesia.

This note aims to summarise the presentation given during the seminar on biodiversity protection and invasive species management in French Polynesia, held in Mahina, Tahiti, from 28 to 31 October 2013. Its purpose is to:

- give an overview of the applicable biosecurity and environmental protection texts; and
- consider legal solutions to the difficulties encountered to implement the regulations.

What are the applicable legislation in French Polynesia?

The 2004 Statute of Autonomy of French Polynesia, an overseas country within the French Republic, gave it general jurisdiction in all matters not devolved to the State and communes.

In this framework, it understandably enacted a set of regulations designed to protect its biodiversity and manage invasive species in line with the following two key objectives:

Environmental protection

Part I of the Environmental Code is dedicated to this issue, while chapter 3 specifically deals with invasive species management. It particularly bans the introduction of new species and lists 35 plant and 11 animal species as threatening the biodiversity of Polynesia and being subject to destruction.

Animal and plant disease control

Forty key regulations, amended as required, govern biodiversity and animal and plant disease control. Country law n° 2013-12 of 6 May 2013 defines the general framework for biosecurity in French Polynesia. Other texts complement this set of regulations to cover issues such as human health, consumers and fraud. Enforcement officers have to choose between the various penalties or protection objectives that best fit the situation.

Such objectives might be environmental or biodiversity protection, animal and plant disease control, human health protection or economic or customs fraud. This choice will also determine the jurisdiction of the public entity in charge of the case. As for penalties, they can be either administrative (seizure of the item, authorisation withdrawal, financial sanction, etc.) or criminal (fine and/or prison sentence depending on the texts and national legal sanctions).

However, despite its statutory jurisdiction, French Polynesia's regulatory measures are limited by the wording of its Statute of Autonomy and the general principles governing French law. While it can for instance add criminal penalties to its laws, such penalties cannot exceed those provided for under French law for the same offences. And, to be enforceable, any prison sentence stipulated in Polynesian regulations must first receive the national legal approval of the French Parliament. The approval of prison sentences can take up to 3 years. Similarly, its sworn enforcement officers do not enjoy general jurisdiction over the whole of French Polynesia and must be specifically commissioned for each matter to be enforced. The specialisation of sworn enforcement officers complicates the on-the-ground implementation of the regulations since the number of officers must be multiplied according to the areas to be enforced. The size and fragmentation of the territory further complicate the issue. Today, it is clearly impossible to enforce the regulations throughout French Polynesia.

What are the legal solutions for enforcing regulations throughout French Polynesia?

Resource pooling is the only conceivable solution given the above mentioned constraints and the fact that invasive species management is "everyone's business".

Two legal solutions can be envisaged:

- reinforcing departure controls; and
- reinforcing entry controls.

Reinforcing departure controls

The French Polynesian administration is highly centralised around the city of Papeete. Beside its status as the main international gateway, the urban centre of Papeete also acts as the hub for connections to other islands. It is also the main administrative centre of the country, where enforcement officers can easily be mobilised. The idea is, therefore, to reinforce departure controls. To this end, besides the existing regulations and powers of cognizance, French Polynesia can reflect on the opportunity of increasing the powers of investigation of its sworn officers. Today, only judicial police officers can carry out investigations to look into offences. Sworn officers can only report offences once they have been committed.

However, Article 31 of the Statute of Autonomy provides for the sharing of the powers of investigation, subject to the adoption of a country regulation, specifically approved by a decree issued by the Prime Minister. Today, such a national approval has only been granted for the economic regulations, with officers commissioned to enforce these regulations authorised to investigate offences. The departments in charge of environmental protection and biosecurity have also sought such national approval, but are yet to receive a response. This procedure will take some years.

Reinforcing entry controls

The other solution consists in reinforcing controls upon entry in the islands. This solution can only be envisaged through the communes, each of which is headed by a mayor, a judicial police officer and deputies; all holding powers of enforcement and responsible for the public safety and peace on the territory of the commune. In this context, a simple police order from the mayor would allow the adoption of invasive species management measures. For example, the communes of Rimatara and Ua Huka, the only Polynesian islands without black rats, could apply rat control measures to all ships reaching its shores, with the municipal police enforcing their implementation. As representative of authority at the local level and first port of call for its population, the head of the commune is undoubtedly a key element of the system to be put in place.

To conclude, French Polynesia's legislative framework is by and large satisfactory. The key challenge is for everyone to play a part in the overall management of invasive species.

APPENDIX 1: Standard Operating Procedure - Application of granular baits to control little fire ants

Purpose and Scope

This standard operating procedure describes recommended methods for treating little fire ant (*Wasmannia auropunctata*) nesting on the ground or in vegetation under 1.5 metres in height. This standard operating procedure should only be used by persons who have undergone practical training in this activity.

Introduction

Little fire ants nest on the ground, around houses and other structures and in vegetation, including the canopy of mature trees. Treatment for control of colonies nesting on the ground or in low vegetation (less than 1.5 metres) is accomplished most easily with granular baits. For treatment of colonies nesting in trees and vegetation, please refer to the standard operating procedure for gel baits.

Materials

- Granular ant bait (see below)
- Hand held or motorized bait spreader
- Nitrile or latex gloves
- Long pants, long sleeved shirt, shoes and socks (mandatory)
- Dust mask and eye protection (if desired)

Method

Treatment with granular baits is intended to deliver an even distribution of the bait over the soil surface at an approximate rate of 2 kilograms per hectare. Most, but not all, granular baits manufactured for control of red imported fire ants (*Solenopsis invicta*) are suitable for control of little fire ants.

Granular baits are mostly manufactured using similar ingredients for the bait matrix with the active ingredient differing from brand to brand. The matrix is comprised of corn grits and vegetable oil. The oil is soaked into the grits resulting in light, fine granules 1mm – 3mm diameter. The product is usually a bright yellow colour and has a faint odour of vegetable oil. Once the bait container has been opened, the unused product will degrade over approximately 3 months, eventually spoiling. Opened bait containers should be stored in a cool dry location. Unopened containers more than two years old are likely to be spoiled also. Bait that is spoiled will have a rancid odour and should not be used.

Application

Two main application methods are used: hand-held spreaders and motorized blowers. There are also spreaders that can be attached to tractors or ATV vehicles for treatment of larger areas.

Hand-held spreaders

These are available at low cost from hardware and pesticide stores. They feature a hopper for holding the bait, a winding handle that agitates the bait and scatters it over the ground, and an adjustable aperture that is used to calibrate output. These spreaders are also used to scatter seeds and fertilizer.

With the aperture set at "1" (see above figure) the operator winds the spreader handle at approximately 60 rpm while walking at 2-3 mph. The swath width thus created is approximately 4 yards. When applying the bait over the target area, an overlapping series of parallel swathes is recommended. This is accomplished by starting on one boundary of an infested site and proceeding 1 yard inside the boundary. Once the operator reaches the end of the treatment area, he or she takes 2-3 paces towards the untreated area and returns parallel to the original path, working around buildings and other obstacles (see below). Continuing this process, the designated area can be systematically covered. It is important that all ground is treated including spaces between buildings and corners of gardens. An additional sweep around buildings, garden edges and other structures is recommended. Rainfall within 12 hours of treatment will reduce effectiveness so plan to conduct treatment when rain is not expected for 12 hours.

Improving the agitator

Typical hand held bait spreader showing the winding handle (a) the aperture adjustment (b) and correct grip. Set the aperture at 1.

Ant bait is light and fluffy. Often it does not feed through spreaders evenly, and two main alterations should be considered: The agitator is the orange plastic "T" shaped device in the bottom of the hopper. This can easily be pulled out. Wrap a small cable tie around the stem and tighten the tie as tightly as possible. Then cut it down so an inch or so is left sticking out. The cable tie should wrap around the stem in an anti-clockwise direction when viewed from above so when it is in the hopper, it is wrapped the way shown in the figures below. Cut the cable tie down to leave a one inch end after placing it onto the stem so it will be easier to tighten. This will assist the bait to flow more evenly.

Holding the aperture adjuster open for long periods can cause discomfort and fatigue for operators. The trigger can be locked in place simply by inserting a self-tapping screw through the assembly while holding the aperture open at the desired setting. Usually #1 is sufficient, but a better position is half way between #1 and #2. Drill a small pilot hole and drive a self-tapping screw through the assembly so the trigger remains open.

Motorized blowers

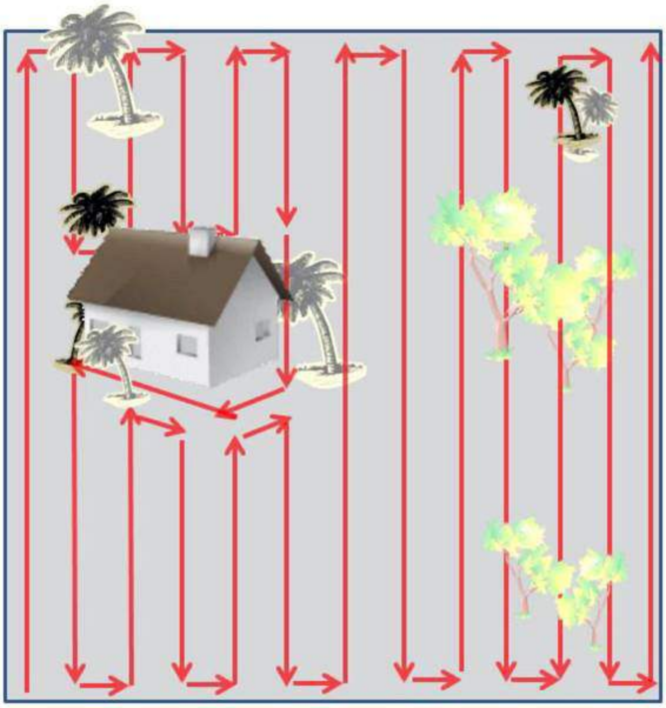
Motorized blower-misters can be used to cover large areas quickly and offer several advantages:

- Blowers can project granular baits more than six metres
- An operator can cover much greater area in the same time, and
- Granules can be blown into areas that are not easily accessible

Their disadvantages include high purchase costs, a requirement for gasoline and specialized maintenance, additional weight and difficulty calibrating output. Several manufacturers produce these machines, with a common one being made by Maruyama.

Choosing baits for control of little fire ants

Many baits manufactured for control of red imported fire ants are effective against little fire ants. However, some are not attractive to little fire ants and these should not be used. Both the Hawai'i Ant Lab and Dr Arnold Hara of the University College of Tropical Agricul-



Example of a treatment path taken by an operator treating around an urban structure.

ture and Human Resources have tested many baits available in USA. Together, their research shows that baits containing methoprene or pyriproxifen as the active ingredient are NOT effective against little fire ants, while those containing hydramethylnon, indoxacarb and fipronil work best. Below is a table of ant bait formulations that are attractive to little fire ants and therefore recommended. There may be other bait products available from other countries, however, use this as a guide for baits sourced from the United States.

Some product formulations suitable for control of little fire ants.

Product brand	Manufacturer	Active ingredient	Concentration	EPA registration number
Amdro Block® Amdro Fire Ant Bait®	BASF	Hydramethylnon Hydramethylnon	0.880 %	73342-2
Probait®	Zoecon	Hydramethylnon	0.730 %	73342 -1-2724
Maxforce Complete® Maxforce Fire Ant Killer	Bayer	Hydramethylnon Hydramethylnon	1.000 % 1.000 %	432-1265 432-1265
Advion fire ant bait®	Dupont	Indoxacarb	0.045%	352-627
Maxforce FC Fire Ant Killer®	Bayer	Fipronil	0.00045%	71106-GA-001
Siesta Fire Ant bait	BASF	Metaflumizone	0.063%	969-232

Cautions

The active ingredients in ant baits may affect aquatic life to varying degrees. Extreme caution should be taken when selecting and applying baits near water bodies, both salt and fresh water. It is recommended the LC50 (96hr) for *Oncorhynchus mykiss* or a similar measure be used to select the least toxic option for use near waterways. Further, operators should be trained and all label provisions for safe application should be followed when using these products.

Some product formulations suitable for control of Little Fire Ants.

APPENDIX 2: Standard Operating Procedure - Treatment of little fire ants with gel baits

Purpose and scope

This standard operating procedure describes recommended methods for treating vegetation and structures within a designated outbreak of little fire ant (*Wasmannia auropunctata*). Little fire ants nest on the ground and in vegetation. This means all vegetation needs to be treated in addition to ground treatment. This standard operating procedure should only be used by persons who have undergone practical training in this activity.

Materials

- Gel baits (see mixing instructions in separate operating procedure)
- ZEP brand spray bottle or good quality 2 gallon pump-up sprayer
- Nitrile or latex gloves
- Long pants, long sleeved shirt, shoes and socks
- Hat and eye protection

Method

The intent of treatment with gel baits is to ensure areas not adequately covered by granular baits are also treated. Little fire ants like to nest in trees, vegetation and even the crowns of coconuts. Worker ants from these colonies do not forage great distances and may not always reach the ground-applied bait granules.

The gel bait is made mostly from water and vegetable oil. It is the texture of ketchup and sticks to vegetation when sprayed. The bait is easily applied to cracks, crevices, branches, vertical surfaces etc. and it is therefore very suitable for use on trees, shrubs and buildings. The recommended application rate is 10kg per hectare depending on how much vegetation cover is present. Rainfall within 12 hours of treatment could reduce effectiveness, however, most of the gel baits will remain unless rainfall is very heavy. Aim to produce spatters – small drops of bait between 5-10 mm in diameter, with at least one drop of bait every 30 centimetres.

Every tree, shrub and building structure within the treatment area will need to be treated as follows:

Trees

Vegetation under 6 metres in height can be treated from the ground. Shoot 1-2 squirts onto every limb, branch junctions, hollows, areas with dead wood, areas where debris has collected and along branches. Large trees like coconuts may need to be climbed. Go as high as it is safe to do so and apply several shots into the crown of each coconut, in foot holds and hollows of the trunk. If little fire ants are seen, place additional amounts of bait along foraging trails. The bait should be placed at approximately 1 meter intervals.

Bananas

Banana clumps are a perfect habitat for little fire ants. In infested areas, almost all the spaces between leaf axils and the stem will house a small colony. Spray bait in the areas of the stem where green or dying leaves are attached. Also spray the trash around the banana clump and place some bait along fallen or cut trunks.

Shrubs and small trees

Flowering plants, fruit bearing trees and small shrubs are often used by little fire ants for food gathering. These are generally too fragile to climb but spray across these with an even coverage of “splatters”. If a foraging trail is seen, follow it to the ground and/or to the nest and place some bait there also.

Buildings and structures

The bases of buildings and other structures are places where little fire ants will be found. Work around each building, placing splatters of bait every 30 centimetres or so. The best spots to place baits are cracks crevices, hollows and places where foraging trails can be seen. If ants are seen foraging up walls or posts, place additional bait as high as can be safely reached. Always choose the shady side of posts to place bait as little fire ants prefer to forage in shady locations.

Spray tools

Gel baits can be sprayed with good quality squirt bottles (not the cheap kind). With these sprayer types, it is possible to shoot a thin stream of gel 6-6 metres. This is very handy for spraying vegetation or covering larger areas. As you depress the trigger, wave the wand or bottle in the air to form a shower of smaller droplets. ZEP brand spray bottles work very well, however, different brands are also available. Often these sprayers have a small filter at the bottom of the inlet tube. This needs to be removed prior to use.

Another way to spray larger areas is with a pump-up sprayer. The cheaper types do not work very well. Search for a sturdy model with a wide (13mm) outlet hose that connects to the bottom of the sprayer. The pump assembly must also be good quality as high pressure is needed. The Redmax brand sprayers work well. Make sure the one you purchase has a metal wand or purchase a metal wand separately because it will need to be modified as follows (also see the figures below):

- First, hold the wand in a vice and bend until it snaps. This should leave it almost closed at the tip.
- Squeeze the tip almost closed with a pair of pliers or vice grips. You can drill two very narrow holes in the tip or leave it as it is. Either

Good quality spray bottles

Hold the wand in a vice and bend until it snaps.

This should leave it almost closed at the tip.

Squeeze the tip almost closed with a pair of pliers or vice grips.

You can drill two very narrow holes in the tip or leave it as it is.

Either way, it will need more crimping to get the spray pattern right. Experiment with a batch of blank gel bait. You will need to adjust the tip until the bait squirts out in a nice thin stream. After carefully adjusting it, this should bee able to spray around 5-6 metres, or even fuirther.

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- After carefully adjusting it, this should be able to spray around 5-6 metres, or even further.

Cleaning and maintenance

The gel bait used in this standard operating procedure is viscous and oily. Equipment must be thoroughly cleaned with an industrial degreaser to remove all residues inside the bottles, plungers and wands. If equipment is not carefully cleaned on a daily basis, any remaining oil will harden and block the wand, nozzles and other pump components. Using a heavy-duty degreaser is recommended to thoroughly rinse the tank and spray through the nozzle until only clear soapy liquid emerges. Then rinse out the old cleaner, re-fill with new detergent and allow some to be sprayed through the wand. Leave the degreaser standing in the hoses, tank and wand, and thoroughly rinse immediately before the next time the sprayer is used.

APPENDIX 3: Standard Operating Procedure - Mixing gel baits for control of little fire ants

Purpose and Scope

This standard operating procedure describes recommended methods for mixing a Gel bait for control of little fire ant (*Wasmannia auropunctata*). Gel baits are easier to apply to vegetation where ants frequently nest and are less affected by rain than conventional baits. This standard operating procedure should only be used by persons who have undergone practical training in this activity.

Introduction

The little fire ant (*Wasmannia auropunctata*) is very difficult to control. They have many small colonies, each with many queens, and will have nests on the ground as well as in trees and other vegetation. All these small colonies are inter-connected and if some die out, they are re-populated by neighbouring colonies. One management problem is that virtually all commercial baits consist of small granules. These are easy to spread on the ground, but cannot be applied to vegetation. If only the colonies on the ground are treated, neighbouring ants living in trees will quickly spread back to the ground. The bait granules are also inactivated by rainfall. Once the granules become soggy, they are no longer attractive to ants. Tahiti experiences regular and frequent rain. In some locations it is difficult to predict if it will rain on any given day.

Contrary to popular belief, ants do not eat solids - they only consume liquids. Granular baits are made from corn granules soaked with vegetable oil, and when a worker ant finds a bait granule, she sucks the oil out of the granule and leaves the rest behind. Ants can consume a gel bait far more easily than a granular product, so in theory, gels should be more effective than granules.

Baits in liquid or gel form do not have the same limitations as granular products. They can be applied to vegetation where they will stick to the leaves and branches and are not affected as quickly by rainfall. They are, however, a bit more difficult to apply compared with granular baits. Also, gel baits suitable for the control of little fire ants are not available commercially and need to be prepared before treatment can begin.

Pesticide regulations differ between countries, change over time, and in some cases, the use patterns described here may contravene these regulations. Before employing these methods, it is a requirement to consult with appropriate regulators to ensure they comply with local laws. Currently, the Service du Developpement Rural is the agency responsible for administering pesticide laws in French Polynesia.

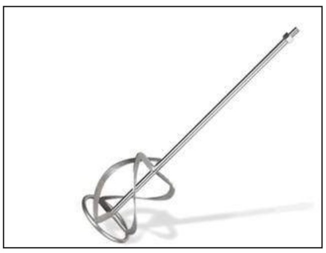
Method

Ingredients

- Toxicant
- Corn, safflower or similar vegetable oil
- Water
- Xanthan gum
- Peanut butter (creamy)

Battery or electric drill

A standard type paint mixer works well.



Another type of mixer.

A kitchen whisk can be modified to fit into the drill chuck.

- Dye or coloring agent if desired

Mixing equipment

- 20 liter plastic bucket with tight fitting lid
- Electric or battery drill
- Whisk or paint mixer
- Measuring jugs
- Scales
- Chemical resistant apron or similar
- Rubber gloves
- Eye protection

Choice of toxicant

The following pesticides have been used experimentally in gel baits against little fire ants (see Table on page 36)

Vegetable oil

Most edible vegetable oils used in cooking appear to be suitable. It is easy to compare palatability of various oil options be presenting foraging little fire ants with a choice of several types and recording which type attracts more ants.

Xanthan gum

Xanthan is an emulsifier and thickener used in cooking.   Addition of this product is necessary to mix the oil and water in a way that does not cause the ingredients to separate before use. It also mixes the toxicant with the oil. Normal xanthan gum is a powder and can be difficult to mix with water. Hot (60-70° C) water will mix a little more readily. Bulk "rapid dispersal" xanthan gum is preferred and is much easier to mix. It is available from Philoutlet, email philoutlet@gmail.com or phone +1 312 733 0000. Normal xanthan is available elsewhere through health food stores and pharmacies.

Choice of toxicant

Product name	Manufacturer	Active ingredient	Concentration in product	Amount product needed per kg bait
Provaunt®	Dupont	Indoxacarb	300 g/kg (wettable powder)	
Avaunt®				6.0 grams
Termidor®	BASF	Fipronil	100 g/kg (suspension con-centrate)	0.5 grams
Tango®	Wellmark Inter-national	S-methoprene	49 g/kg (suspension con-centrate)	51 grams
Various	Various	Boric acid	99.9 g/kg powder	20 grams

Peanut butter

Any creamy or smooth variety is acceptable. The cheaper brands are best as they are already homogenized making them easier to mix.

Colouring

It may be desirable to add food colouring or other edible dye to make it easier to observe where treatment has taken place. However, colourings may also stain structures, concrete and plants.

Mixing Procedure

This method uses quantities sufficient to make 8 kilograms of gel bait. Make the bait mixture the afternoon before it is needed. The mixture will not keep fresh for more than 2-3 days.

- Add 4.8 liters of water and toxicant to the bucket.
- Mix with drill and whisk until thoroughly incorporated.
- Slowly add 64 grams of xanthan gum to the water while mixing. Make certain to add the xanthan powder slowly so that it does not form lumps. Continue to mix until a uniform jelly-like consistency is achieved.
- Add 2.8 kg oil and 240g peanut butter. Continue to mix until all the oil is combined with the water and a consistent color and texture is achieved.
- Sometimes small lumps form in the mixture despite best efforts to avoid them. In this case, leave the mixture overnight and mix again in the morning just prior to use.

Mixing devices

A battery or electric drill with a kitchen whisk or a paint mixer works best for mixing. The best type of drill is one with higher speed (RPM). Standard type paint mixers work well. Others prefer a kitchen whisk modified to fit into the drill chuck.

APPENDIX 4: Standard Operating Procedure - Surveillance and monitoring methods for little fire ants

Purpose and scope

This standard operating procedure outlines procedures and specifications for detection, delimitation and quarantine inspection of commodities for the little fire ants (*Wasmannia auropunctata*).

Introduction

There are three main survey types: detection surveys, delimiting surveys and inspection for quarantine purposes. (The standard operating procedure for quarantine inspection can be found in a separate document). Each survey type has a different aim and the type of information that needs to be gathered is also different. In a detection survey, the objective is to determine if a site does, or does not, have an invasive ant. This is the easiest type of survey to conduct because all that is needed to confirm presence of the ant is a single specimen. In delimiting surveys, the purpose is to map the extent of an infestation. For quarantine detections, the goal is to determine if a commodity is infested with the target species.

Detection of ants can be accomplished by several means including visual searches, placement of long term trapping devices like pitfall traps or by placing lures of attractive food items within the survey area. The use of lures has several advantages for most survey types including low cost, ease of deployment and systematic nature. Briefly, lures that are attractive to the target species are deployed in a grid pattern over the search area, left exposed for sufficient time to be discovered by the target species, then collected and the specimens identified by a trained taxonomist.

Little fire ants are consistently attracted to peanut butter, so this makes a good lure. Depending on the nature of the survey, there are two recommended lure designs: a bait stick, or a vial. Preparation of these two lure types are detailed below.

Planning the survey

When planning the survey, work out the area to be covered and obtain a map or aerial image of the site. Google Earth is a good source of maps but most ports have port plans which can also be used. Contact site management at least a day before the survey to make sure you have permission to enter and arrange any passes etc. that might be needed. In the case of an airport or sea port, try to pick a time when no planes are expected or ships are being loaded/unloaded. Also, plan to conduct the survey during clear weather when rain is not expected.

Lure preparation (bait stick method)

When field identification is possible, or only a few specimens are anticipated, surveys can be conducted with the bait stick method. This is the most rapid survey method but is the least accurate if detailed information such as ant density is needed.

Materials

- Disposable chopsticks (cut in half), disposable coffee stirrers or popsicle sticks
- Bright-coloured spray paint
- Smooth peanut butter
- Zip-lock bags
- Marking pen
- GPS unit

Preparation and deployment

Paint both sides of the chopsticks or coffee stirrers with bright-coloured spray paint (this makes locating deployed sticks much easier). Once the paint has dried, grab a handful of sticks and dip them into the jar of peanut butter. Withdraw the sticks and place them into a zip-lock or other plastic bag with the peanut butter end inside the bag. Pull the sticks out one by one as needed, making sure to leave only a thin smear of peanut butter on each stick. Place the sticks in specified locations and at a spacing determined by the type of survey to be conducted.

Collection

Leave the lures in the field for 45-90 minutes and then retrieve them. If the collector can identify little fire ants in the field, take a GPS waypoint at every location where little fire ants are detected. If the samples are to be returned to the laboratory for identification, place the sticks individually into a zip-lock bag. Seal the bag, take a waypoint and write the waypoint number onto the bag. This way, positive samples can be mapped after they have been identified. Place samples in a freezer at -18°C until ready for identification.

Lure preparation (vial method)

When all samples need to be returned to a laboratory for identification, the vial method may be the best alternative.

Materials

- Clear plastic vials (30-60 CC) with lids.
- Smooth peanut butter

- Marking pen
- GPS unit

Preparation and deployment

It's best to make only enough baits for a day's work. This way the baits will be fresh and attractive to ants (ants are not as interested in old baits). If possible, make them up the day before and store them in a refrigerator overnight.

Smear a thin layer of peanut butter onto the inside of each vial. Replace the caps and store prepared samples in a carry bag ready to take into the field. Place the vials in specified locations and at a spacing determined by the type of survey to be conducted.

Collection

Leave the vials in the field for 45-90 minutes and then retrieve them. Take a GPS waypoint at every location where a vial has been placed and write the waypoint number onto the vial. Make certain to keep one collector's vials separate from other collector's vials and ensure a record of waypoint numbers and GPS coordinates accompany the vials to the laboratory. This way, positive samples can be mapped after they have been identified. Place samples in a freezer at -18°C until ready for identification.

Conducting the survey

The aim of the survey is to thoroughly sample the ants at the site. This is done by placing baits in a grid pattern over the entire area, placing protein baits and sugar baits alternately. The spacing between baits should be around 10 paces for general detection surveys. It is not important to have the grids at exactly this spacing as long as they are approximately correct. See Table 1 for survey specifications for different types of survey. Sections of the survey site that are all concrete or asphalt do not need to be sampled because few ants nest in these locations. Common ant habitats are listed in Table 2 and it is important that these are all sampled.

Bait vials should be collected 45-90 minutes after placement. It takes much less time to retrieve vials than it does to deploy them. As a guide, teams should place vials for one hour, then stop and retrieve the vials they have deployed in the order they were deployed. This way, the vials placed at the beginning will have been out for 60 minutes and the ones deployed last will have been exposed for about 45 minutes depending on ant species. Try to plan out a route that will take you back to the point where you started – it saves extra walking.

Surveillance should not occur during or after rain when the ground surface is still wet, or on windy days. Also no rain should fall between placement of bait traps and their retrieval. If rain is imminent, it is a good idea to stop deploying baits and retrieve the ones already out. If this is not possible, collect the baits one hour after the rain has stopped. If not many ants are at the baits, it might be necessary to re-survey the rain-affected section.

Bait vials should be placed in the shade where possible. Remember the sun might have moved by the time you collect the vials so place them carefully to avoid this. As a hint place your vials with the opening away from prevailing wind and angle the entrance slightly to the ground. This helps prevent vials filling with water and debris if you encounter a sudden down pour.

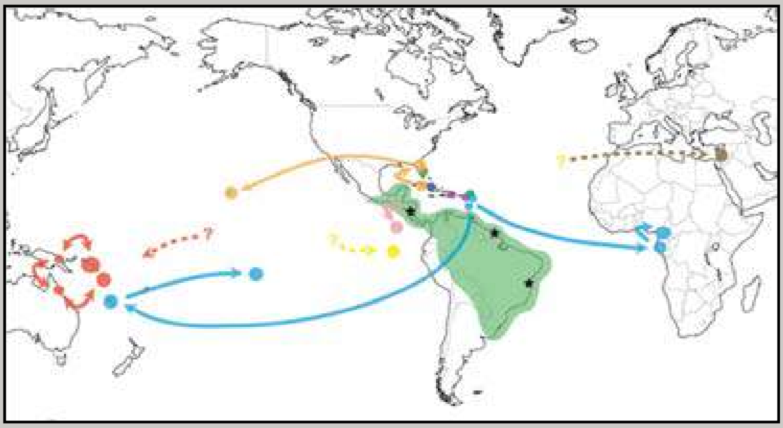
Any unusual ants (that look different from common established species) sighted while conducting surveillance should also be collected.

Table 1. Specifications for surveys

	Detection survey	Delimiting Surveys	Commodity inspec-tion
Methods	Vials	Vials or bait sticks	Bait sticks or visual
Lure spacing	200-400 / ha, 1 vial every 5-7 m depending on available resources	100 / ha, 1 vial every 10 m. Once no ants detected, switch to 1 vial every 5 m at least 20 m beyond the limits of detection	Visual inspection of 1 % of commodity or bait sticks in 1-10 % of pots for potted plants.
Frequency/ length of program	Six monthly annually (2 rounds per year)	Immediately, if results negative follow up every six months for 2 years. If results positive, treat and monitor out to delimiting boundary	As needed
Buffer zone	50m	20m	
Visual Surveillance	Very efficient in high density areas especially if surveyors are familiar with the ant. Habitat is three dimensional- in soil, intermediate canopy, vegetation, target bananas and coconut trees first. A good visual method is to use a smear of peanut butter on a bait stick.		

Table 2. List of common ant habitats

1.	Tree trunks (visual inspection and bait at base if appropriate)
2.	Flowers and trunks of trees
3.	Shrubs and poles
4.	Building edges and foundations
5.	Concrete slab edges
6.	Cracked concrete
7.	Disturbed sites
8.	Drains and culverts
9.	Electrical generators and fittings
10.	Exposed rocks
11.	Fence palings
12.	Grass areas
13.	Verges
14.	Hot water pipes and heaters
15.	Isolated weeds
16.	Logs
17.	Loose gravel
18.	Low vegetation (including grass)
19.	Plant pot bases
20.	Road margins
21.	Rubbish piles
22.	Soil
23.	Tree crotches and hollows
24.	Vertical surfaces
25.	Weed and plant re-growth
26.	Wooden structures
27.	Underneath stones or concrete rubble



The spread of *Wasmannia auropunctata* or the little fire ant, native to South America, continues unabated causing hardship to farmers and communities.

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