


The 2016 Fiji Ant-Mealybug Bioinvasion

Threat to Food, Health, Livelihood, Cultural and Environment Security in the Pacific Islands

R. R. Thaman

PACIFIC CENTRE FOR ENVIRONMENT AND SUSTAINABLE DEVELOPMENT

Publication No.1 (2018)

Pacific Centre for Environment and Sustainable Development (PaCE-SD)
The University of the South Pacific
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USP Library Cataloguing-in-Publication Data

Thaman, R. R., 1943-
The 2016 Fiji ant-mealybug bioinvasion : threat to food, health, livelihood, cultural and environment security in the Pacific islands / R. R. Thaman. -- Suva, Fiji : USP Press, 2018.
130 p. ; 30 cm.
ISBN 978-982-01-0975-9
1. Ants--Fiji. 2. Mealybugs--Fiji. 3. Insect pests--Fiji. I. Title.
QL568.F7T53 2018
595.796099611--dc23

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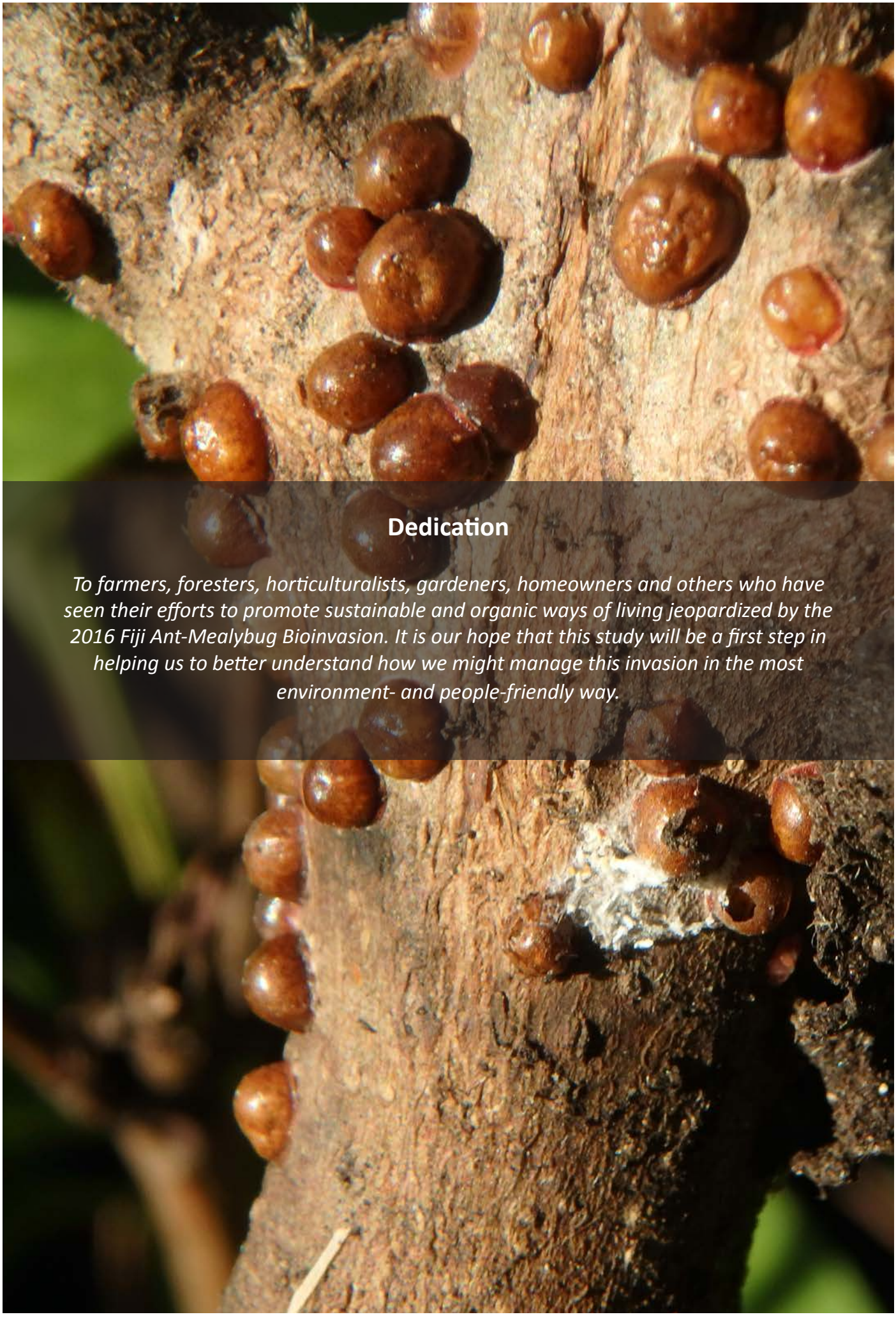

Coffee Brown Scale (*Saisettia coffeae*)

Dedication

To farmers, foresters, horticulturalists, gardeners, homeowners and others who have seen their efforts to promote sustainable and organic ways of living jeopardized by the 2016 Fiji Ant-Mealybug Bioinvasion. It is our hope that this study will be a first step in helping us to better understand how we might manage this invasion in the most environment- and people-friendly way.

THE AUTHOR

Emeritus Professor of Pacific Islands Biogeography, Randy Thaman, has worked for The University of the South Pacific (USP), Suva, Fiji for the past 44 years. During this time he has travelled to, studied and photographed Pacific Island plants, animals, islands and peoples in all of USP's 12 member countries, as well as in Papua New Guinea, New Caledonia and French Polynesia. As an acknowledged expert on island biogeography and ethnobiology, Pacific trees and plants, marine biodiversity, invasive alien species and sustainable island development, Randy has taught and mentored many current and past Pacific Island leaders, teachers and scientists. In partnerships with his students, colleagues and local communities, he has conducted research, co-authored and published widely on plants and agroforestry (Agroforestry in the Pacific Islands, Trees of Life: A Guide to the Trees and Shrubs of USP, Plants of Nauru, Plants of Tuvalu and the Flora of Kiritimati Atoll), marine biodiversity (Fishes of Tuvalu and Tokelau) and ethnobotany (Traditional Medicine of the Marshal Islands).

Plumeria rubra, PR, USP

1 Introduction

This paper is about the recent biological invasion of Fiji's cities, villages, homes, garden lands and islands by ants and mealybugs, scale insects and a number of other sap-sucking insects and diseases that form alliances with, and are tended by this highly invasive black ant. This multi-pronged invasion, hereafter referred to as the 2016 Fiji Ant-Mealybug bioinvasion, is perhaps the latest historical example of the devastation of indigenous peoples, plants, animals, islands and the ecosystem goods and services they depend on by invasive alien species (IAS) in the Pacific Islands.

Since Elton (1958) reported the seriousness of the impacts of bioinvasions on native biological communities, invasive alien species (IAS) have been recognised as a major driver of the loss of biodiversity and ecosystem services (BES)[2], particularly on islands (MacArthur and Wilson 1967; Williamson 1981; Simberloff 1995; Jourdan 1997; UNEP 2014), with over 75% of all extinctions since 1600 having occurred on islands, particularly oceanic islands (Goombridge 1992). There are innumerable cases within the Pacific Islands where IAS (e.g., alien mammals, birds, reptiles, amphibians, fishes, molluscs, insects, echinoderms, terrestrial and aquatic weeds, fungi and a vast array of infectious diseases and micro-organisms) have led to extinctions of indigenous mammals, birds, amphibians, reptiles, land crabs and snails and insects; the loss of traditional plant cultivars; and negative economic, social and environmental costs and threat to human health associated with of the use of toxic pesticides to control IAS (Thaman 1984; Thaman 2011; Thaman 2013).

Most IAS that have historically invaded oceanic island groups, such as Fiji, Samoa, Tahiti and Hawaii, have come from the continents of Asia, Australia, Africa and South America or from continental islands, such as the islands of Indonesia and Papua New Guinea, where they evolved in competition with their own predators, parasites and diseases which had controlled their numbers. When introduced into new, less-competitive oceanic island ecosystems, where there are few indigenous predators, parasites and diseases, these more competitive continental organisms, which are commonly introduced without their original predators, parasites and diseases, have a distinct competitive advantage and outcompete and displace the naïve indigenous island organisms that have evolved in isolation in less-competitive oceanic island ecosystems. Moreover, most IAS reach sexual maturity early, reproduce in large numbers and are well-adapted to disturbed habitats, which gives them further competitive advantages with clearly increasing disturbance and habitat degradation due to human actions and extreme events, such as devastating tropical cyclones (Simberloff 1995; CGAPS 1996; MA 2005; Thaman 2011; Simberloff et al. 2013; Thaman 2013; Butler and Bax 2014). Table 1 highlights some of the more serious IAS and the impacts they have had on islands.

[2] Ecosystems, the plants, animals and organisms they contain and the goods and services (tangible and intangible) they provide to humans (Diaz et al. 2013.)

Table 1. Examples of some of the more serious IAS and the historical impacts they have had on the islands of the APR.

- Post-European impact devastation of indigenous Pacific Islands peoples, including almost half of the indigenous Fijian population, by epidemics of introduced diseases, such as tuberculosis, influenza, smallpox, typhoid, measles, whooping cough, syphilis and other venereal diseases, to which they had little resistance (Mac Arthur 1968; Martin and Combes 1996; Miles 1997; Anderson 2000).

- Extinction of endemic birds, fruit bats and geckos and the reduction of bird-dispersal and reproduction of new trees by as much as 60—90% in Guam due to the introduction of the brown tree snake shortly after World War II (Rodda et al. 1992; CGAPS 1996; Baskin 2003; McCrae 2017; Rogers et al. 2017).

- Widespread extinction and drastic population declines of birds, land snails and land crabs in Hawaii, French Polynesia, Rotuma and many other Pacific Islands due to combinations of avian malaria, rats, mongooses, cats, pigs, goats, ants, predatory land snails, flatworms and habitat degradation (Howarth 1985; van Ripper et al. 1986; CGAPS c. 1996; Thaman 2013; Brodie et al. 2014; PIAT 2016).

- Widespread loss of biodiversity and human discomfort and negative social impacts due to alien ants, such as the little fire ant *(Wasmannia auropunctatus)*, which has been introduced into New Caledonia, Solomon Islands, Vanuatu and Wallis and Futuna, where it has made subsistence food gardening difficult and become a major pest of coconuts, cocoa and citrus fruits and other plants and forms negative symbiotic relationships with scale insects, mealybugs and other crop pests (Jourdan 1997; Le Briton et al. 2003; Fasi et al. 2013); and the yellow crazy ant (YCA) *(Anoplolepis gracilis)*, which also forms alliances with scale insects, has had devastating impacts on land crabs, seabirds, indigenous insects and spiders, pigs, chickens, tree regeneration and crops on Christmas Island in the Indian Ocean (O'Dowd et al. 2003) and in Samoa, Tuvalu, Tokelau and elsewhere in the Pacific (Auina et al. 2011; Gruber et al. 2012; Vaqalo et al 2014; PIAT 2016). In Tuvalu the YCA has displaced or supressed other ants on even some of the smallest uninhabited islets (Vaqalo et al. 2014), and in Australia, the YCA has invaded over 200 hectares of rainforest in and adjacent to the Wet Tropics World Heritage Area near Cairns and over 500 hectares of adjacent residential land and cane farms, A draft 2012 cost-benefit analysis by the Queensland government, considering only limited impacts on agriculture and dwellings, found that costs would range from $115 million to over $3 billion if the ants were not controlled (Lasch and Hoskin 2015).

- Invasion of cropland and secondary forest in Fiji by the invasive African tulip tree *(Spathodea campanulata),* which takes up to one-third of the cropland in some areas and outcompetes and impedes the natural regeneration of a wide range of culturally valuable pioneer tree species that were formerly part of sustainable multispecies fallow cropping systems (Thaman 2011, 2013, 2014);

- Devastation of taro production in Samoa by the taro leaf blight *(Phytophthora colocasiae)*; in Fiji, Solomon Islands and PNG by the taro beetle (*Papuana* spp.) and/or along with Alomae and Bubone viral complex in Solomon Islands and PNG (Alolii et al. 1993; Hunter et a. 1998; Thaman 2014; Tsatsia and Jackson 2016).

- Abandonment of cultivation of hibiscus spinach *(Abelmoschus manihot)*, the most important green vegetable and cash crop in the Solomon Islands due to the accidental introduction from PNG in the early 1980s of the Aibkia beetle *(Nisotra basselae)* and the giant African snail *(Lissachatina fulica)*, which was discovered in the Solomon Islands in 2007 and reportedly eats over 500 species of plants (Tsatsia and Jackson 2009a; Pestnet 2013)

- Discovery and recent devastation of the papaya export industry and other fruit trees in the Cook Islands in 2013 by the oriental fruit fly *(Bactrocera dorsalis)*, which reportedly attacks over 150 species of fruits and vegetables and native fruits (Allwood *et al. 1999*; Vargas et al. 2007; Weems et al. 2012; Wilson 2013).

- The virtual disappearance of dadap or coral tree *(Erythrina variegata var. orientalis)* an important nitrogen-fixing, live fencing and cultural tree in Hawaii, Fiji, Samoa and other countries due to the highly invasive African Erythrina gall wasp *(Quadrastichus erythrinae)* (Campbell 2010; Thaman 2011); and in 2012, on Nanumea Atoll, Tuvalu, the devastation of beach cordia *(Cordia subcordata)*, the main woodcarving and coastal protection species, by infestations of kou leafworm *(Ethmia nigroapicella)* (Thaman 2011; Thaman and O'Brien 2012).

- Asian subterranean termites *(Coptotermes gestroi)* have, in Fiji, since the mid-2000s caused millions of dollars losses in housing and destroyed livelihoods, in addition to over a millions dollars in control costs and the need for the use of very toxic chemicals (BAF 2014)

- Marine invasive species, such as algae, plankton and echinoderms, such as the crown-of-thorns starfish *(Acanthaster planci)* are also an increasing concern (Coles et al. 1999; Butler and Bax 2014; N'Yeurt and Iese 2015).

As suggested above, the 2016 Ant-Mealybug Bio-invasion of Fiji's cities, villages, homes, garden lands and islands by alien ants in symbiotic relationships with a range of mealybugs, scale insects and other associated insects and diseases constitutes, perhaps, the most recent and serious IAS invasion in the Pacific. With little or no assistance from designated authorities, this seemingly unstoppable biological juggernaut invades and reinvades our properties and destroys our plants, leaving homeowners, gardeners, horticulturalists and conservationists helpless. For many, the 2016 Fiji Ant-Mealybug Bio-invasion seems as serious and certainly more bothersome, more immediate and less understandable than climate change, natural disasters and environmental degradation. Like climate change, but unlike natural disasters and oil spills, these IAS constitute a living pollution that seemingly won't go away and will probably only get worse over time (Thaman 2013b).

The paper discusses 1) the origin, timing and nature of the 2016 Fiji Ant-Mealybug Bioinvasion; 2) the diversity of invasive organisms and host plants that have been affected; 3) emerging environmental, economic and social impacts of the invasion; 4) possible reasons for the seriousness of the invasion; 5) a preliminary assessment of what can be done to manage the invasion without further damaging our health, cultures, economies and environment; and 6) suggestions of areas of investigation for future studies. The study is based on; 1) a review of information on the ants, mealybugs and other insects that are part of the invasion, infested host plants, information on other ant-mealybug bio-invasions, and control measures that have or could be employed to control the invasion; 2) a four-month-long field study of the presence and diversity and seriousness of impacts of this invasion at over 40 sites in Fiji, during which voucher photographs were taken of ants, mealy bugs and other associated insects and pathogens on infested host plants, and a tabular database prepared of infested species, IAS responsible and levels and locations of infestations; 3) discussions with gardeners, horticulturists, agriculturalists, conservationists, homeowners, tourism operators and hospitality providers in Suva and other parts of Fiji's main island Viti Levu about the invasion, its impacts; and 4) discussions and correspondence with entomologists, plant scientists and other authorities on biological invasions. The main motivation behind the study is to better understand and raise awareness of the seriousness of the invasion, which had seriously impacted the author's own garden and property and the gardens and properties of many friends and other Fiji residents, and to explore what has been, and might be, done to arrest the invasion. All photograph are those of the author, unless otherwise stated.

Acknowledgements

During the study, many people have shared their knowledge and allowed me to examine the plants in their gardens. Among those who I would like to give thanks (in no special order) are Richard Titoko, Dick Watling, Bob Gillett, Petero Manoa, Mosese Uluiciciya, Ken MacDonald, Kiran Lal, Linikoni Vakauta, Konai Helu Thaman, Seini Tuiteci, Semi and Dorothy Duaibe, Josua Wainiqolo, Maclean Vaqalo, Monica Gruber, Gilliane Watson, Gilianne Brodie, Mani Mua, Peter Maddison and Grahame Jackson). Special thanks are also given to Professor Elisabeth Holland, Director, and Dr. Morgan Wairiu, Deputy Director, of the Pacfic Centre for Environment and Sustainble Development (PaCE-SD) for strongly supporting the publication and distribution of this report; Dr. Antoine N'Yeurt who proof-read the manuscript; and Chris Ward who was responsible for the layout and production of the final edition. To those of you who helped and I have failed to acknowledge, please accept my sincere thanks and apologies.

2 The 2016 Fiji Ant-Mealybug Bioinvasion

Most people first became aware of the 2016 Fiji Ant-Mealybug Bio-invasion almost two years ago in early 2016 when hordes of "new" black ants invaded their properties, buildings, homes, gardens and privacy. Ants were seen zigzagging across walls, window screens, steps and kitchens and found in cupboards bookcases and other areas, especially where sugar, tinned fish oil, meat or food pieces were left unprotected or un-cleared (Fig. 1).

These ants colonised gardens, nurseries, greenhouses, garages, washhouses, waste places, open lots and countless other locations . . . including electronic equipment, such as wiring, light fixtures, computers and printers. Regardless of whom you talk to, whether in Suva, Lami, Tamavua or peri-urban Nausori, Western Viti Levu or in rural villages and settlements, most people have been plagued by these ants that seem to appear and disappear whenever you turn your back or challenge them, seeming to have displaced other previously common ants.

More recently (for most of us early 2017), many of us began to see our citrus, breadfruit, jackfruit, guava, avocado, soursop, other fruit trees and our hibiscus, ixoras, gardenias, island musk **(uci)** and other ornamentals and culturally important plants invaded by these same ants and encrusted with white, downy, cotton-like accumulations or yellow-white scale-like infestations that seemed to be accompanied, tended or farmed and protected by the ants. The leaves of many affected plants were also infested on the upper surfaces by black sooty mould that inhibits photosynthesis by the leaves (Schmaedick 2007). Together these seemingly inseparable allies have become an extremely irritating, hard-to-control and costly invasion of our buildings, properties and gardens, killing and damaging many of our most important food, multipurpose and ornamental plants. With little or no assistance or guidance from designated authorities, this seemingly unstoppable juggernaut has invaded and reinvaded our properties, destroyed our plants and left most homeowners, gardeners, horticulturalists and conservationists helpless, save for those who have discovered the “silver bullet” (a simple solution to a complicated problem) or have resorted to the use of large amounts of Mortein, Raid, Orthene or other insecticides, the use of which constitutes a serious, but poorly understood, health and environmental hazard.

2.1 Identity, Origin and Spread of the Ants, Mealybugs and other Associated IAS

As suggested above, the ant-mealybug bio-invasion is led by a superabundant, highly invasive new black ant in strong symbiotic relationships with a number of invasive sapsucking mealy bugs and scale insects (from the superfamily Coccoidea - scales and mealybugs) and other sap-sucking or plant-damaging insects, such as aphids, and fungal pathogens, such as black sooty moulds. The super-abundant new black ant, which seems to have displaced pre-existing invasive ants over the past two years of so, has been identified as either the difficult white-footed ant (*Technomyrmex difficilis* Forel, 1892) or the common white-footed ant (*Technomyrmex albipes* Smith, 1861), hereafter referred to as WFA (Fig. 1). Of the almost 20 mealybugs or scale insects and other sapsucking insects, with which the WFA seems to form symbiotic alliances (Table 2), some of which are responsible for the downy, mould- or snow-like and scale-like plant infestations and the death or damage to plants are: 1) Seychelles scale (SS) or mealybug (*Icerya seychellarum* (Westwood, 1855), from the Giant Scale Insect Family (Monophlebidae), by far the most abundant species, which is found on most host plants; and 2) pink hibiscus mealybug (PHM) *(Maconellicoccus hirsutus)* from the Mealybug Family (Pseudococcidae). These three will be discussed in some detail below, along with some other discussion and other associated uncents and pathogens.

Fig. 1. Super-abundant white-footed ants (WFA) (*Technomyrmex* sp.), which have spearheaded the Fiji 2016 Ant-Mealybug Bioinvasion of Fiji, on a kitchen sink, Suva September 2017 (left) and WFS tending Seychelles Scale (SS) on the underside of an avocado leaf, Suva, June 2017 (right).

As the survey progressed, it became clear that, in addition to these more common species, there were other mealybugs, scale insects, aphids and other sap-sucking insects and plant pathogens that that were also associated with WFA and part of the invasion, often infesting the same plant hosts along with SS and/or PHM (Table 2).

Table 2. Polyphagous mealybugs, scale insects, other sap-sucking insects and plant pathogens observed and identified (some tentatively) as being present on host plants in apparent symbiotic infestations with WFA, based on field studies in Suva and other selected locations on Viti Levu Island, Fiji by R. Thaman from May to September 2017 (Notes: 1) the main host plants include those plants seen to be most commonly infested in Fiji and/or reported to be important hosts overseas; 2) the identification of some organisms is tentative pending microscopic analysis of specimens).

Scientific Name	Common Names	Code.	Main Host Plants	Sources
Icerya seychellarum	Seychelles scale, breadfruit scale	SS	citrus, breadfruit, guava, avocado, mango, soursop, beans, tamarind, rain-trees and other legumes, casuarina, coffee, figs and banyans, palms, heliconias, gardenias, roses, anthuriums and other Araceae, *Acanthaceae, Malvaceae*	ALA 1999; CABI/EPPO, 2008; Idtools. 2014a; CABI 2016b; Jackson 2016a

Scientific Name	Common Names	Code.	Main Host Plants	Sources
Maconellicoccus hirsutus	Pink hibiscus mealybug	PHM	hibiscus, beach hibiscus, ixora, okra, red ginger, soursop, breadfruit, chillies, capsicum, citrus, garderias cotton	NISIC 2015
Planococcus citri	Citrus mealybug	CTM	citrus, mango, soursop, guava, carambola, coffee, cucurbits, sweet potato, chillies, pineapples, basil, gardenia, heliconias, croton, gingers, cycads, *Ficus, Morinda, Ocimum, Solanum and Macaranga* spp.	Watson 2016, CABI 2017
Nipaecoccus nipae.	Coconut mealybug, spiked mealybug	CMB	coconut and other palms (e.g., (*Pritchardia, Caryota, Sabal, Veitchia*), avocado, citrus, bananas, papaya, guava, soursop, taro, red ginger, anthuriums, philodendrons, crotons, *Calophyllum,*	Pestnet 2006 CABI 2016a
Icerya aegyptiaca	Breadfruit mealybug	BMB	avocado, banana, citrus, jackfruit, mango, soursop, taro, giant taro, pandanus, coconut, ornamentals.	Jackson 2015
Dysmiscoccus brevipes	Pineapple mealybug	PMB	pineapple, pandanus, sugarcane, banana, plantain, avocado, citrus, coconut, coffee, custard apple, guava, ginger, figs, mango,	CABI 2017
Saisettia coffeae	Coffee brown scale, hemispherical scale	CBS	coffee, breadfruit, citrus, guava, Hibiscus, soursop, cassava, figs and banyans, heliconias, ornamental plants, especially cycads	Tsatsia and Jackson 2016e
Parasaisettia nigra	Nigra scale	NS	cordyline, anthuriums, bamboo, coffee, cotton, croton, gardenia, eggplant, fig, ginger, guava, macadamia, ornamentals, pineapple, *Urena lobata*	Idtools 2014b

Scientific Name	Common Names	Code.	Main Host Plants	Sources
Aulacaspis yasumatsui	Asian cycad scale	ACS	cycads, *Cycas* spp.	Weissling, and Howard 2017
Quadraspidiotus perniciosus	San Jose scale	SJS	cycads	CABI 2017c
Bambusaspis bambusae	Soft bamboo scale	SBS	bamboo	Hodgson and Łagowska 2011; CABI 2012
Pseudococcus longispinus	longtailed mealybug	LTM	*Endospermum* sp., ginger, palms, taro, cassava, avocado, guava, eggplant	NISIC c. 2014
Chrysomphalus aonidum	circular scale	CS	Citrus, Dracaena, *Barringtonia* spp.	NISIC 2015
Coccus hesperidum	brown soft scale	BSS	Cordyline, papaya, *Cordia myxa*, *Ablemoschus,* citrus	NISIC 2015, CABI 2017a
Protopulvinaria pyriformis	pyriform scale	PS	Cordyline, mango, avocado, citrus, banana, guava, passionfruit, papaya, hibiscus, gardenia, frangipani	NSWDPI 2015
Ceroplastes rubens	pink wax scale, red wax scale	PWS	gardenia, citrus, ixora	Leathers 2016
Ceroplastes (Vinsonia) stellifera	stellate scale	STS	Schefflera, gardenia	Watson 2017
Aleurodiscus dispersus	spiralling whitefly	SWF	banana, cassava, citrus, papaya, mango, custard apple, guava, taro, tomato, capsicum, chilies, eggplant, plumeria, poinsettia, ornamental species, *Urena*	Tsatsia and Jackson 2016c
Earias vittella	Abelmoschus (bele) shoot borer, spotted boll worm	ASB	bele (*Abelmoschus manihot*), okra, hibiscus, tomato.	Tsatsia and Jackson 2016b
Aphididae, including possibly *Toxoptera citricidus*	aphids	APH	*Crassocephalum, Thunbergia*	Halbert and Brown 2014
Capnodium and *Tripospermum* spp. plus others	black sooty moulds	BSM	Coconut, guava, plumeria, ti-plant (*Cordyline*), soursop, Annona spp., citrus, mango, gardenia	Tsatsia and Jackson. 2016d
Coleospermum plumeriae	plumeria rust, frangipani rust	PR	frangipani, Indian shot (*Canna indica*)	Nelson 2009; Jackson 2016b

Among the more common of these other insects or pathogens are coconut mealy bug (CMB) *(Nipaecoccus nipae)*; citrus mealybug (CTM) *(Planococcus citri)*; pineapple mealybug PMB) (*Dysmiscoccus brevipes*); possibly breadfruit mealybug (BMB) *(Icerya aegyptiaca)*; coffee brown scale (CBS) *(Saisettia coffeae)* and/or nigra scale (NS) *(Parasaisettia nigra);* Asian cycad scale (ACS) *(Aulacaspis yasumatsui)*; soft bamboo scale (SBS) *(Bambusaspis bambusae)*; spiralling white fly (SWF) *(Aleurodiscus dispersus)*; aphids (APH) (Aphididae); bele or *Abelmoschus* shoot borer (ASB) (*Earias vittella*); *brown* and *yellow aphids (Aphididae)*; black sooty moulds (BSM) (*Capnodium and Tripospermum* spp. plus others) and plumeria rust (PR) *(Coleosporium plumeriae)* (Table 2)(See figures below related to individual plant taxa).

2.2 White-footed Ant (WFA)

The WFA, which varies in length between 2—3 mm, is a dark-brown to black ant with a distinctly pointed abdomen and contrasting whitish lower parts of the legs (Pacific Biosecurity 2016). It is part of an Old World species group, several of which have broad distributions, resulting in numerous misidentifications because the difficult white-footed Ant *(T. difficilis)* looks similar to and is often confused with other ants, including other white-footed ants, such as the apparently indigenous Fiji white-footed ant (*Technomyrmex vitiensis,* Mann, 1922) and the common white-footed ant *(Technomyrmex albipes)*, and some other widespread tramp ant species, such as the Argentine ant *(Linepithema humile)*, a serious invasive species in many areas, and some of the crazy ants, (*Paratrechina* spp.), all of which are present in Fiji (Wetterer 2008; Sarnaat and Economos 2012; Warner and Scheffrhan 2016).

Apparently native to Madagascar, where it was first reported present in 1892, the difficult WFA began spreading through Southeast Asia and Oceania more than 60 years ago and was first reported in the New World in 1986 where, until 2007, it was misidentified as *Technomyrmex albipes* (Forel 1892, 1911; Wetterer 2013), with Bolton (2007), believing that all recently published records of *T. albipes* from Australia and some of the published records from Pacific Islands (Wilson and Taylor 1967) were probably also *T. difficilis*, although, as Bolton (2007) stressed, in the absence of specimens, the actual identity of many published *T. albipes* records “must remain equivocal” (Wetterer 2013).

The relatively recent arrival of WFA *(T. difficilis)* in most of the Pacific is supported by Wetterer (2013) who reported that it was neither among the 15 tramp ant species spread by human commerce reported by Forel in 1911 to have achieved almost cosmopolitan distributions (eight of which had had already become major ecological, agricultural, and/or household pests), nor was it among several other serious invasive ant species to subsequently become cosmopolitan during 20th century.

In the Caribbean, WFA was first recorded at a nursery in Florida in 1986 and was subsequently found present in Puerto Rico in 1996 and on at least 7 other islands, most recently in the Bahamas and Jamaica in 2007. Although first recorded in the western Pacific in Guam and the Federated States of Micronesia as early as 1946 and 1953 (possibly introduced during or just after WW II) and in Australia in 1972, it was first reported from in Hawai'i in 1994 and Papua New Guinea in 2007 (Wetter 2008; Hodgson and Lagowska 2011; Wetterer 2013); and it was not reported present by Sarnaat and Economos' in *Ants of Fiji* in 2012, although the related, apparently endemic or indigenous, species, *Technomyrmex vitiensis* Mann, which is difficult to differentiate from the WFA, was reported present near Nadarivatu in central Viti Levu in 1921; and *T. albipes* (F. Smith), which is considered to be synonym for *T. vitiensis*, a species reportedly indigenous to New Guinea and Melanesia, was reported present on all of the larger islands in Fiji by Ward and Wetterer in 2009.

It was only in 2013, however, that Wetterer said: "One emerging cosmopolitan pest ant species, now spreading rapidly through Florida and the West Indies is *Technomyrmex difficilis* FOREL, 1892", which, as stressed above, until 2007, was commonly misidentified as *Technomyrmex albipes* (Wetterer 2013: 93). Given, its rapid recent spread in the Caribbean, it is probably safe to suggest that WFA has recently spread from Australia, Papua New Guinea, Micronesia or Hawai'i into Fiji and other parts of the Western and Central Pacific.

2.3 Seychelles Scale (SS)

The Seychelles scale (SS) *(Icerya seychellarum)* is also known as the Seychelles mealybug or breadfruit scale or mealybug (Jackson 2016). The adult female SS are oval, somewhat tortoise-shell-shaped, about 6-9 mm long by 4 mm, initially yellow becoming light brick-red to light orange body covered by a white to yellow-white powdery wax; the median areas have longitudinal series of tufts and fluted protuberances and marginal areas with a fringe of wax processes of similar length and with fine silky white hairs. Ovisacs produced below and behind females and covered with silken threads and small flutes. SS females are hermaphroditic and males are rare. Eggs are light orange, laid inside ovisacs, immature insects are yellow and males are uncommon. It is dispersed by windblown crawlers (Idtools 2014; ALA 2014; Jackson 2016; HIJI 2016)(Fig. 2).

Fig. 2. Seychelles scale (SS) *(Icerya seychellarum)*, also known as the Seychelles mealybug or breadfruit scale or mealybug seen on leaves of avocado *(Persea americana)*(left) and chenille plant *(Acalypha hispida)*, Suva, Fiji, 2017.

Like the WFA, the SS is possibly native to Africa or the Indian Ocean Islands, such as the Seychelles (after which it was named in 1855), and was one of the earliest reported mealybugs from the Mascarene Islands, where it was reported present in Mauritius and Reunion as *Coccus saccharin* in 1867 (Pestnet 2014), It subsequently spread to South Asia, with many of the earliest documented reports coming from India (Rao 1951), and the type specimen, which is lodged at the Smithsonian Institution National Museum of Natural History, collected in 1905 in Manila, Philippines (ALA 2017). Interestingly, in 1896, W.W. Markell, the eminent New Zealand entomologist and acknowledged world expert on coccid insects, identified a specimen with no recorded place of origin which is lodged in the DSIR Entomology Division in New Zealand; and, given the fact that SS was not reported from Australia, NZ or the Pacific Islands until recently, it almost certainly came from Asia, from where he was reportedly sent coccid specimens for study and identification (Morales 1993). The SS has also been reported from other Indian Ocean islands, including Zanzibar, Comoros, Mauritius, Reunion, Rodrigues, Andaman and Nicobar Islands and the British Indian Ocean Territory (CABI/EPPO2008; EPPO 2014; CABI 2016). Seychelles scale was also first discovered in 1968 on Aldabra atoll in the far north of the Seychelles, the world's second largest atoll and one of the most isolated uninhabited islands on Earth, where the SS seriously impacted the native vegetation, threatening the survival of some woody species (SIF 2017). It had not been reported present by early expeditions to the atoll (Hill and Newbery 1980). There are also studies of interactions between SS and ants on Aldabra, where SS were reportedly attended by large numbers of ants that seemed to stimulate the SS to produce more honeydew (Hill and Blackmore 1980).

The presence of SS has also been documented from most of Africa and throughout South and Southeast Asia, including Nepal, Pakistan, Sri Lanka, China, Hong Kong, Thailand, Malaysia, Brunei, Indonesia, Irian Jaya, Japan (including the Ryukyu Islands) and Taiwan; (CABI/EPPO2008; EPPO 2014; CABI 2016). It has also been reported present in parts of southern Europe and was first collected in Australia in 1990 (CABI/EPPO2008). In the Pacific, it is now widespread and was first collected and identified present in the Pacific Islands in the Cook Islands and Niue in 1933 (ALA 2016); on Tutuila in American Samoa at least by the 1950s (Dumbleton 1954; Schmaedick 2007); in Fiji by the mid-1940s (Lever 1946, 1947); in the Federated States of Micronesia in 1985; in Australian Northern Territory, Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia, Kiribati, Tuvalu, Samoa by 1990; and in Fiji, Tonga, Palau, Nauru, and French Polynesia and New Zealand by 2008 (Williams 1985; Williams and Watson 1990; CABI/EPPO2008; EPPO 2014; CABI 2016). Most recently, it has been reported present as a serous pest in the Caribbean islands of Guadeloupe, Martinique and Dominica (DNO 2015; CABI 2016; ALA 2016). These data indicate that SS was probably present in Fiji by at least 2008.

2.4 Pink Hibiscus Mealy Bug (HMB)

The pink hibiscus mealybug (PHM) *(Maconellicoccus hirsutus)*, which is also known as the hibiscus, pink or grape mealy bug, is a small oval-shaped, soft-bodied, pink to greyish-pink sap-sucking scale-like female insects, about 2—3 mm long, that is covered with clusters of downy white wax-like egg sacs containing eggs that are laid by dark-pink wingless mature females on the leaves, growing tips, terminal buds, branches and the bark of host plants. The slightly smaller pinkish-brown adult winged males have two long waxy tails (Meyerdirk et al. 2001; RADA 2013).

Figure 3. Pink hibiscus mealybugs *(Maconellicoccus hirsutus)* on beach hibiscus, **vau** *(Hibiscus tiliaceus)* leaves *(left)* and on the growing tip of a hibiscus hybrid *(Hibiscus rosa-sinensis)* (right), Suva, Fiji, May 2017.

The PHM is one of about nine species in the genus Maconellicoccus, which is, like DWF and SS, probably of East Asian and/or possibly tropical Australian origin, where five of the nine species are found. Like the WFA, the PHM is the only species of its genus that has now spread worldwide throughout the tropics and subtropics (Meyerdirk et al. 2001; OEPP/EPPO 2005), and is now considered a serious pest in tropical and subtropical regions of Africa, Southeast Asia and Northern Australia and more recently in the Caribbean, where it was first reported present in Granada 1993 and subsequently spread to most islands in the region (Serrano *et al.* 2001), as well as to Florida, California and Louisiana, and was reported from Jamaica for the first time in 2007 (Warner and Scheffrhan 2002). Although it was first reported present in the Pacific in Hawai'i, Guam, Palau, Federated States of Micronesia, Solomon Islands, Vanuatu, Tonga, Samoa and Tuvalu by 2004 (CABI/EPPO 2004; OEPP/EPPO 2005), it was first reported from Fiji by Hodgson and Lagowska in 2011. Given their close association and the similar times of reported presence in the Caribbean and parts of the Pacific, it is not implausible that the WFA and the PHM were introduced together into some of these locations.

3 Invasiveness, Pest Status and Impacts of WFA, SS, PHM and other IAS

As stressed above, the WFA is a super-abundant, rapidly spreading and hard-to-control urban, household, garden and forest pest that has a strong symbiotic relationships with SS, PHM and a range of other destructive polyphagous mealybugs, scales and other sap-sucking insects. Together, they constitute a rapidly spreading and seemingly almost unstoppable multi-pronged juggernaut that is infesting and/or destroying our properties, gardens and many of our important food, multipurpose, ornamental and native plants. Their invasiveness and impacts are discussed briefly below.

3.1 White-footed ants (WFA)

Although white-footed ants (WFA) (*Technomyrmex* sp.) do not bite or sting and are not reported to cause structural damage, they form large colonies estimated to contain from 8,000 to 3 million individuals. The colonies have 'normal' queens and workers, intercaste workers and flying queens and an unusual dual mode of reproduction, with reproduction in established colonies being carried out by intercaste workers and new colonies being founded by flying mated queens, which enables colonies to build up rapid numbers, making the control of WFA more difficult. The WFA nests at or above ground level close to sources of food and moisture and, although more commonly found outdoors rather than indoors, such as on the bases, trunks, branches, leaves, flowers and fruits of trees, bushes, and in trunk holes and wood piles and under rubbish, leaf litter or debris and, as we all know, they also make their nests inside walls and in cupboards, bookcases, attics, storerooms and garages in houses and in nurseries and other structure in urban and rural areas (Warner and Scheffrhan 2002; Pacific Biosecurity 2016). WFA are also abundant and lay eggs within the dry leaf sheaths of coconut leaves that are still attached to the trunk and within the fibrous mesh surrounding new leaves at the crown of the tree, as well as in-between overlapping striated leaves of some plants (N'Yeurt, pers. com.)

WFA are strongly attracted to sugar and sweet foods and feed voraciously on protein, especially tinned fish, pieces or blood from meat that are left on kitchen counters or tables and dead insects, such as cockroaches and moths. They are most commonly found foraging along branches and trunks of trees and shrubs and on leaves and flowers, in symbiosis with sap-sucking and honeydew producing insects, such as mealy bugs, scales and aphids. Large groups of foragers also leave nests to search for new food sources, after which they lay trails of pheromones between the food sources and nests to lead new recruits to the food sources, with some trails being observed for months at a time. Outside homes and other structures, foragers tend to follow lines, such as along edges of wall panelling, doors or window frames or other paths that eventually lead to small openings to the interior, where ants that enter become more noticeable to occupants, frequently finding their way inside walls or ceilings where they follow electrical cables and emerge into rooms, especially kitchens and bathrooms, where liquid, sugars, proteins and other foods can be found (Warner and Scheffrhan 2002).

As such, the WFA is considered a serious hard-to-control nuisance and a health concern by home owners, businesses, tourism facilities and other institutions; and a particularly devastating agricultural and horticultural pest because they feed in large numbers on plant nectars and "farm", protect, and feed on the honeydew produced by sap-sucking insects, such as mealybugs, scale insects and aphids, which also help promote other plant diseases, such as black sooty moulds (BSM) that feed on honeydew residues on the leaves. As the ants move from one plant to another, the mealy bugs are transported with the ants to other plants (Warner and Scheffrhan 2002; JIS 2007; ISSG 2009; Wetterer 2013). Ants also interfere with natural and introduced biological control agents by attacking parasites and predators, thus further protecting mealybugs and other sap-sucking insects (Bugs for Bugs 2015a).

In Florida. where by 2005 WFA had spread to all southern and central countries, it was predicted that within the "next few years" the ant "will likely saturate urban and suburban habitats in central and south Florida . . . and possibly spread throughout the state", where one of the most important means of spread appeared to be via transportation of infested residential landscaping plants and materials (Warner and Scheffrhan 2002; Warner et al. 2016). This is borne out by our experience in Fiji. Unlike some other alien tramp ant species, WFA also seems to be able to colonise intact native forest, as of 2013, it had become the dominant arboreal ant in numerous areas of Florida and the West Indies where it can impact native plant and animal species (Wetterer 2013), something that must be further investigated as a grim prospect in Fiji.

3.2 Seychelles Scale (SS)

The Seychelles Scale *(Icerya seychellarum)*(Fig.2 above), which is also known as Okada cottony-cushion scale, silvery-cushion scale and breadfruit scale, is an extremely polyphagous scale insect that sucks sap or nectar from host plants from over 60 families from all zoogeographic regions except the Nearctic. It is clearly the most abundant polyphagous and destructive or all the insects in association with WFA in Fiji. It is especially invasive on woody plants, such as avocado, guava, breadfruit, citrus, soursop and Figs (*Ficus* spp.*)* and *Casuarina* spp. and a wide range of indigenous woody plants, a pattern also seen in Fiji (Newbery and Hill 1985; CABI 2016; Jackson 2016). The crawlers can actively spread from infected to healthy plants; small crawlers are transported by wind, rain, irrigation water, birds, ants and on clothing and animal hair to new plants; and the waxy coating facilitates passive transport of the insects by sticking to equipment, animals or clothing, although longer distance movement is commonly done via the transport of infected plant materials (El Wanis 2010).

Seychelles scale is found on leaves, stems, twigs, flower buds, fruit and roots, most commonly or on the underside of leaves near the lower midribs and on terminal stems. Heavy infestations lead to yellowing of leaves, abnormal leaf fall, death of young shoots, stunting and dwarfing and, in some cases, the death of entire plants.

Honeydew is produced by SS when feeding on the phloem, which is in turn fed upon by ants and fungi, the later which forms the black sooty moulds that infest the topsides of leaves and the fruit of many host plants, thus limiting photosynthesis and making the plants and the fruit unattractive. Studies also show that the serious damage caused by mealy bugs and scale insects, which can lead to the death of plants, may be due more to the toxic substances in their saliva that are injected into the plant tissue during feeding (ALA 2016; CABI 2016 Jackson 2016).

Between 1995 and 2012, SS was intercepted 30 times on a variety of hosts at U. S. ports-of-entry; some of the countries of origin along with genera of infested host plants that were intercepted include: American Samoa *(Alyxia)*, Cambodia *(Mangifera)*, Cook Islands *(Alyxia)*, Fiji *(Murraya)*, India *(Citrus, Murraya)*, Indonesia *(Citrus)*, Malaysia *(Nephelium)*, Mexico *(Leucaena)*, Philippines *(Arachnis, Artemisia, Citrus, Codiaeum, Lagerstroemia, Lansium, Musa, Nephelium, Psidium)*, Singapore *(Euphorbia)* and Tahiti (*Gardenia, Mangifera, Musa, Psidium)* (ALA 2016; CABI 2016). Most of these are genera also infested in Fiji.

The most relevant long-term study of the impacts of SS is from the isolated Indian Ocean atoll of Aldabra, where SS was first discovered in 1968 and where, by 1975, Renvoiz's (1975) study of all the main vegetation types showed that of 65 infested woody species, 27 were heavily infested and 38 lightly infested. He predicted a subsequent loss of one-third of the species in mixed scrub and up to two-thirds reduction in the entire vegetation cover. Later studies of 55 woody plant taxa showed that by 1975, when SS reached peak densities, 21 species were 'heavily' infested and 21 'lightly'/'moderately' infested (76% of all species). Interestingly, by the end of 1978 no species were considered to be heavily infested but 37 remained 'lightly'/'moderately' infested, with the state of vegetation showing negligible change between the 1976/77 and 1978 surveys (Hill and Newbery 1980). Studies in the late 1970s, did show, however, that in association with ants, SS had seriously threatened some woody species including the small indigenous tree, *Euphorbia pyrifolia*, the widespread coastal shrub, *Scaevola taccada*, and the mangrove, *Avicennia marina* (Hill and Blackmore 1980, Newberry 1980a, b, c). The studies showed that infested *E. pyrifolia* plants produced about one-third of the leaves and had a growth rates less than 50% of non-affected plants (Newberry 1980a); that SS was the major cause of reduced leaf production by about 60% and the main cause of the death of up to 50% of the studied *Scaevola* plants. The studies also showed that SS densities were greatest on senescing leaves with infestations increasing with distance from the sea; and that SS infestation were most serious on older *Avicennia* mangroves, many which were subjected to poor drainage, which may have increased their susceptibility to attack and possibly also because salt secretion on the leaves of young trees served as a barrier to the establishment of SS (Newberry 1980abc). Most recently, 1983 surveys showed that, although the overall abundance of SS had changed little between 1978 and 1983, its spatial distribution over the atoll had markedly changed with the level of infestation having risen in the SE, where tree mortality was largely density independent, but had remained low in the NW, where tree mortality was more density dependent; and several susceptible host tree species had showed ten-fold or higher median infestation levels in the SE of the atoll (Newbery and Hill 1985).

In American Samoa, since the 1990s, repeated severe outbreaks of SS reportedly heavily impacted breadfruit and other plants on Ta'u in American Samoa (Schmaedick 2007). There were no available reports of SS infestations and resultant damage from other Pacific Island countries.

3.3 Pink Hibiscus Mealybug (PHM)

The PHM, although less common and less obtrusive and visible, is, like SS, a polyphagous invasive species that reportedly feeds on plants from 76 families and over 200 genera, causing significant damage, yield loss or death of many valuable plants (Meyerdirk et al. 2001; OEPP/EPPO 2005; NISIC 2012). As reported in *The Georgia Gardner:*

> If you think fire ants and armadillos are terrible exotic, invasive pests, just wait until you have a houseplant infested with pink hibiscus mealybug (PHM). The damage this insect does to plants makes them look like weed killer was sprayed on them (Reeves n.d.).

The PHM is considered a serious pest in both tropical and subtropical regions including Africa, Southeast Asia, northern Australia and most recently the Caribbean, the south-eastern USA and the Pacific Islands where it attacks food plants, tree crops, vineyards, ornamentals, weeds and forest trees, as well as attacking indoor and glasshouse plants. In 1995, in Grenada and Trinidad and Tobago, it reportedly caused over US$150 million direct damage in addition to export losses and property and environmental damage (Meyerdirk et al. 2001; RADA 2015; Bugs for Bugs 2015); and it was estimated that PHM could cause losses of $750 million if it were to spread across the southern USA (OEPP/EPPO 2005). The destruction has not been as serious in Hawaii, where it seems that its natural enemies from South Asia or Australia were fortuitously introduced along with it (Meyerdirk et al. 2001).

As stressed above, like SS, PHM is dispersed, tended and protected from its predators by ants, by WFA in Fiji, which feed on the sap or honeydew produced by the PHM. It is also spread on plants, fruits and other plant parts by humans and by other animals and wind. PHM breeds rapidly and, even without a male, one mature female can lay over 600 eggs which hatch in in 3—8 days. Both the eggs within the white egg sacs, which are initially orange but turn pink on maturity, as well as the immature and adult females are pink in colour. The newly hatched mealybug nymphs, which are known as crawlers, settle on host plants and start their development that takes 10 to 25 days. Under optimum laboratory conditions PHM can produce 15 generations per year and 10 generations per year in the subtropics, where, if there is a cold or winter season, all growth phases hibernate or remain quiescent, remaining hidden in cracks in the bark, stems, in fruit bunches or in the soil, until it is warmer again and host food plants return or bear flowers and fruit (APIS 1996; Meyerdirk et al. 2001; JIS 2007, RADA 2015).

Although adult female PHM are not particularly mobile, the nymphs, crawlers and males can migrate with air currents; and the females, nymphs and crawlers are mobile enough to move from host to host within infested areas. It is often hard to see, unless you check closely because it is most commonly found on the tender undersides of leaves, commonly concentrated along the lower part of the leaf midrib near the petiole and may be hidden in cracks/crevices, such as in the bark, on spathes (e.g., on palms), within folded petioles or stems of leaves or within the shrivelled growing tips or flowers of plants such as hibiscus. Although they prefer the growing tips, flowers buds and tender parts of host plants, the crawlers also infest other plant parts where they develop into winged male and wingless female adults that migrate to the lower parts of host plants as the apical portions wither away. Although adult females normally lay their eggs on the apical or terminal parts of plants, when the weather get colder eggs are laid in more sheltered places on the plant. Because of these cryptic characteristics and because ants protect it from natural enemies, effective chemical control of PHM is very difficult given the diversity of its hosts, its rapid reproduction and ease and rapidity of spread (Meyerdirk et al. 2001; JIS 2007, RADA 2015).

Like SS, during feeding, PHM injects toxic poison into plants which causes malformation, distortion, shrivelling and stunting of leaves and shoots, and in many cases ultimately death of the plant. On heavily infested plants, such as hibiscus (after which the PHM is named), the infested leaves becoming twisted or crinkled leading to “bunchytop”, growth is stunted and flowers either do not form or dry up, remain in a stunted or shrivelled state or, if directly infested, flowers may be small or drop off. Similar but less distinctive damage may occur on the trunks, stems, leaves, flowers, fruits and even roots systems of other culturally and ecological plants. On some plants, such as guava and gardenia, a heavy, black sooty mould which feeds on the PHM’s honeydew secretions develop on the leaves (APHIS 1996; Meyerdirk et al. 2001; JIS 2007; NISIC 2012), which inhibits photosynthesis and makes the affected plants very unattractive which serves as a disincentive to planting vulnerable ornamental species in home gardens, botanical gardens, tourism facilities and other areas.

3.4 Other Ant-associated IAS

As stressed above, a range of other ant-associated mealybugs, scale insects and other sap-sucking insects and pathogens, some quite common, are found on the same host plants as ants and SS and PHM (Table 2). Most common are coconut or spiked mealybug (CMB) *(Nipaecoccus nipae)*(Fig. 4), first reported from Fiji in 2009 (Pestnet 2006); and probably citrus mealybug (CTM) *(Planococcus citri)*(Fig. 5), which was first reported present in Australia in the 1980s and from most Pacific Islands in 1999 (Watson 2016). Like SS and PHM, both are very polyphagous sap-sucking insects that are found on many of the same host plants as SS and PHM (e.g., citrus, guava, banana, papaya, soursop, bullock's heart, red ginger, heliconias, ginger, gardenia, Indian mulberry, coconut palm and a range of other palms, including the endemic, Fiji fan palm *(Pritchardia pacifica).*

Fig. 4. Bullock's heart, **uto ni bulumakau** or **ramphal** *(Annona reticulata)* fruit infested with coconut mealybugs *(Nipaecoccus nipae) tended by white-footed ants (Technomyrmex* sp.), Legalega Research Station, Nadi. September 2017

Fig. 5. Indian mulberry or noni, **kura** or **achi** *(Morinda citrifolia)* fruit infested with citrus mealybugs *(Planococcus citri)* tended by white-footed ants (*Technomyrmex* sp.), Faculty of Science, Technology and Environment, USP Laucala Campus, Suva, August 2017.

Also common are a number of scale insects, including coffee brown scale (*Saisettia coffei*)) (Fig. 6), the adult which has a shell- or coffee-bean shape and shiny brown colour, which is found on soursop, breadfruit, guava, citrus, coffee, and cycad (Tsatsia and Jackson 2016); nigra scale *(Parasaisettia nigra)*, another a polyphagous scale with an elongate slightly convex oval body, ranging in colour depending on the host from translucent yellow to brown or black with no obvious wax covering, the distribution of which is now almost cosmopolitan and has been recorded on hosts from over 94 plant families (Mau and Kessing 2007; Idtools 2014); brown soft scale (BSS) *(Coccus hesperidum)*; pyriform scale (PS) *(Protopulvinaria pyriformis)*, a light brown scab-like scale surrounded by a thin white waxy fringe, another polyphagous species that is particularly common on *Cordyline* (Fig. 6), which was first reported from Western Australia in mid-2015, but which was intercepted at US ports of entry between 1995 and 2012 on host plants originating in all regions except Australasia, but including Hawaii, Micronesia, Asia and most of South America and the Caribbean (IDtools 2013; NSW DPI 2015); and circular scale *(Chrysomphalus aonidum)*, which can be mistaken for juveniles of other scales species, which especially affects citrus trees, commonly leading to death of the trees (NISIC c. 2015). Like the other mealybugs and scale insects, these damage plants by direct feeding and injecting toxins that cause leaves to be spotted, deformed, wilting or dying early and the fruits to be smaller and produce honeydew that encourages the development of black sooty moulds (Table 2).

Fig. 6. Tree cassava or Ceara rubber tree (*Manihot carthagenensis* ssp. *glaziovii*) leaves, Muanikau, Suva, September 2017 (left) and white ixora, **sinu ni vavalagi** *(Ixora finlaysoniana)* trunk, Governors Museum Themed Restaurant, Suva, May 2007 (right) both infested with coffee brown scale *(Saessetia coffeae)* tended by white-footed ants (*Technomyrmex* sp.), September 2017.

Fig. 7. Ti-plant, **vasili** *(Cordyline fruticosa)* leaf infested by pyriform scale *(Protopulvinaria pyriformis)*, Mac-Gregor Rd., Suva (left) and fish-poison tree, **vutu rakaraka** *(Barringtonia asiatica)* leaf base infested by both circular scale *(Chrysomphalus aonidum)*(below) and coffee brown scale *(Saisettia coffeae)*, Queen Elizabeth Dr., Suva (right), both tended by white-footed ants, August 2017.

The breadfruit or Egyptian mealybug or Egyptian fluted scale *(Icerya aegytiaca)* has also been recorded from Fiji, Samoa and is reportedly widespread in Micronesia and a major pest in Kiribati and atolls of the Federated States of Micronesia. It is possibly still present, but now rare. Found mostly on breadfruit, it is also found on avocado, banana, citrus, jackfruit, mango, soursop, taro, ornamentals and occasionally on giant taro, pandanus, and young coconuts. On breadfruit, the mealybugs, like the current infestation of SS, are found along the midribs and larger veins on the undersides of the leaves and also on the fruit. They suck the sap from the leaves, and heavy infestations cause the leaves to dry up and die (Jackson 2015). In Fiji, they seem to have been replaced by the super-dominant SS.

Other ant-associated invasive insects include spiralling white fly *(Aleurodiscus dispersus)* (Fig. 8) and aphids, possibly the brown citrus aphid *(Toxoptera citrida)*, one of the world's most serious citrus pests (Halbert and Brown 2014) and some other aphids, including an unidentified yellow aphid, all of which are tended my WFA. A serious problem, in addition to sucking sap and injecting toxins into host plants, is that aphids and some of the other sap-sucking insects spread viruses and other diseases, such as the aphid transmitted citrus tristeza closterovirus (CTV) (Halbert and Brown 2014), with one of the most devastating citrus crop losses ever reported following the introduction of brown citrus aphid into Brazil and Argentina, where 16 million citrus trees on sour orange rootstock were killed by CTV (Carver 1978). Although the root cause has not been identified in this survey, there are numerous citrus trees, currently infested by WFA and SS and other associated pests that have been seriously defoliated or have almost died, possibly due to such disorders that clearly started to affect the trees before or during the onset of the current ant-mealybug bio-invasion.

Fig. 8. Spiralling white fly *(Aleurodiscus dispersus) infestation on the underside of a kassod tree (Senna siamea) leaf, USP Upper Campus, Suva, September 2017 (left); and on the underside of a guava (Psidium guajava) leaf, Beachhouse Resort, Nadroga, May 2017 (right), the latter of which is also infested by Seychelles scale tended by white-footed ants*.

Other widespread pathogens associated with the WFA-led invasion included a number of fungal diseases, including black sooty moulds (BSM)(Fig. 9) and plumeria rust (PR). BSM, which are caused by *Capnodium* and *Tripospermum* spp. and a number other species, grow on the honeydew produced by the sap-sucking insects and cover the upper leaf surfaces of many plants, such as guava, citrus, mango, soursop, frangipani, gardenias and palms, with a dense, black, soot-like deposits that inhibit photosynthesis and cause leaf yellowing and loss and stunted plant growth (Kohler et al., 1997; Tsatsia and Jackson 2016d).

Fig. 9. MacArthur palm *(Ptychosperma macarthuri)* with the flowers spathes infested with coconut mealybugs *(Nipaecoccus nipae)* tended by white-footed ants (*Technomyrmex* sp.) and the leaves infested with black sooty mould (BSM), Service St., Suva, June 2017 (left); and leaves of beach cordia, nawanawa *(Cordia subcordata)* infested with BSM, USP Lower Campus, Suva, May 2017 (right).

Plumeria rust *(Coleosporium plumeriae)*, a distinctive bright yellow-orange rust-like fungus which is found on the underside of plumeria (*Plumeria* spp.) leaves (Fig. 10), is apparently native to the Caribbean and from Mexico to South America and was first found in Hawaii in 1991, from where it spread rapidly and is now found in Fiji and most other Pacific Island groups. As the infested areas on the leaves enlarge and coalesce they develop into greyish to brown spots and when severely diseased, leaves may dry, curl, become distorted and fall, with premature defoliation approaching 100 percent on some plants (Kohler et al. 1997; Nelson 2009; Jackson 2016).

Fig. 10. White frangipani, **bua ni vavalagi** *(Plumera obtusa)* infested by frangipani or plumeria rust *(Coleospermum plumeriae)* and Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Beachhouse Resort, Nadroga (left); and red frangipani (Plumeria rubra) infested by frangipani or plumeria rust, USP Lower Campus, Suva (right), both May 2017.

4 PLANTS IMPACTED BY THE WFA–MEALYBUG INVASION

The study showed that almost 300 different plant species or hybrid cultivars from over 180 genera in 65 families were infested by white-footed ants (WFA), Seychelles scale (SS), pink hibiscus mealybugs (PHM), coconut mealybugs (CMB), citrus mealybugs (CTM) and/or other mealybugs or scale insects, sapsucking insects and other ant-associated pathogens, the SS infesting by far the greatest number of species (Tables 3 and 4; Appendices I and II), possibly because SS is more competitive and invasive on mutual host plants, has a stronger mutualistic relationship with WFA or that lack any existing predators, parasites or diseases. The families and genera and the number of infested species in each taxon are shown in Table 4; the full scientific, common and local vernacular names and numbers of infested species in each genus and family are shown in Appendix I; and the full details of the plant names, severity of infestation, parts infested, infesting organisms and study sites visited are shown in Appendix II. Infested plants, the most heavily infested of which are woody vines, shrubs and trees, include a very wide range of food and ornamental plants, culturally important multipurpose plants, timber trees and environmentally important plants, such as nitrogen-fixing and soil- and coastal-protection plants and plants that provide food and habitat for other plants and animals.

Table 3. Total numbers of families, genera and species of plants observed to be affected by DFA and associated mealybug, scales and other insects and pathogen infestations in Fiji based on field studies by R. Thaman from May—September 2017.

Taxon	Families	Genera	Species
Ferns	2	2	2
Gymnosperms	1	1	2
Dicotyledons	47	137	217
Monocotyledons	15	46	77
Total	**65**	**186**	**292**

Table 4. Number of host plant species from specified genera and families observed to be affected in Fiji by WFA in symbiotic infestations along with SS, PHM, other mealybugs or scales, other sap-sucking or damaging insects and pathogens, based on field studies by the author from May—August 2017. Ferns and fern allies and gymnosperms are listed first followed by dicotyledons and monocotyledons (greater detail is provided in Appendix I, which is a listing of the number of species within different genera and families, in the approximate order of severity of infestation and number of species infested, along with the scientific, common and local Fijian names and notes on selected species; and Appendix II is a listing by families in alphabetical order, including information on severity of observed infestations, infesting organisms, parts infested and the study locations at which infestations were observed) (Note: * indicates that the number of species within a given genus, e.g. *Hibiscus*, includes a number of distinct hybrid cultivars and species).

FERNS AND FERN ALLIES (PTERIDOPHYTES) (2 species from 2 genera from 2 families)

Aspidiaceae (1): *Tectaria* (1)
Nephrolepidiaceae (1): *Nephrolepis* (1)

GYMNOSPERMS (2) (2 species from 1 Genus from 1 Family)

Cycadaceae 1 (2): Cycas (2)

DOCOTYLEDONS (217 species from 137 genera and 47 families) (Note: numbers after family name are the number of genera in the family with the total species in parentheses, e.g. 20 genera and 25 species for Fabaceae)

Fabaceae 21 (26): *Flemingia* (2), *Bauhinia* (2), *Cassia* (2), *Vigna* (2), *Calliandra* (2), *Intsia* (1), *Phaseolus* (1), *Derris* (1), *Tamarindus* (1), *Arachis* (1), *Psophocarpus* (1), *Centrosoma* (1), *Senna* (1), *Samanea* (1), *Inocarpus* (1), *Cynometra* (1), *Peltophorum* (1), *Brugmansia* (1), *Adenanthera* (1), *Pterocarpus* (1), *Millettia* (1), *Gliricidia* (1)
Malvaceae 7 (17) *Hibiscus* (9), *Abelmoschus* (3), *Thespesia* (1), *Abutilon* (1), *Malvaviscus* (1), *Urena* (1), *Gossypium* (1)
Rubiaceae 5 (14): *Gardenia* (3), *Ixora* (7), *Coffea* (1), *Mussaenda* (2), *Pentas* (1)

Rutaceae 4 (12): *Citrus* (8), *Euodia* (1), *Murraya* (2), *Micromelum* (1)
Euphorbiaceae 7 (11): *Acalypha* (3), *Euphorbia* (2), *Excoecaria* (1), *Aleurites* (1), *Codiaeum* (1)
Solanaceae 5 (11): *Solanum* (4), *Capsicum* (4), *Brunfelsia* (1), *Brugmansia* (1) *Endospermum* (1), *Macaranga* (1), *Manihot* (1), *Jatropha* (1)
Moraceae 4 (10): *Ficus* (6), *Artocarpus* (2), *Broussonetia* (1), *Morus* (1)
Myrtaceae 3 (9): *Syzygium* (6), *Psidium* (2), *Eugenia* (1)
Acanthaceae 9 (10): *Pachystachys* (2), *Hemigraphis* (1), *Sanchezia* (1), *Blechum* (1), *Eranthemum* (1), *Asystasia* (1), *Odontonema* (1), *Pseuderanthemum* (1), *Thunbergia* (1)
Asteraceae 7 (7): *Eleutheranthera* (1), *Synedrella* (1), *Mikania* (1), *Ageratum* (1); *Cyanthillium* (1), *Crassocephalum* (1), *Youngia* (1)
Annonaceae 3 (7): *Annona* (4), *Polyalthia* (2), *Cananga* (1)
Verbenaceae 3 (6): *Clerodendrum* (4), *Duranta* (1), *Vitex* (1)
Cucurbitaceae 5 (5): *Luffa* (1), *Cucurbita* (1), *Citrullus* (1), *Coccinia* (1), *Cucumis* (1)
Lamiaceae 3 (4): *Ocimum* (2), *Tectona* (1), *Congea* (1)
Convolulaceae 3 (5): *Ipomoea* (3), *Merremia* (2)
Lythraceae 3 (4): *Lagerstroemia* (2), *Cuphea* (1), *Punica* (1)
Oxalidaceae 2 (4): *Averrhoa* **(2),** *Oxalis* **(2)**
Piperaceae 1 (3): *Piper* (3)
Anacardiacee 3 (3): *Mangifera* (1), *Dracontomelon* (1), *Spondias* (1)
Lecythidaceae 2 (3): *Barringtonia* (2), *Couroupita* (1)
Sapindaceae 3 (3): Acer (1), Filicium (1), Pometia (1)
Phyllanthaceae 3 (3): *Bischofia* (1), *Flueggea* (1), *Phyllanthus* (1)
Combretaceae 2 (2): *Quisqualis* (1), *Terminalia* (1)
Apocynaceae 2 (3): *Plumeria* (2), *Alyxia* (1)
Araliaceae 2 (4): *Polyscias* (3), *Schefflera actinophylla* (1)
Casuarinaceae 2 (2): *Gymnostoma* (1), *Casuarina* (1)
Boraginaceae 1 (2): *Cordia* (2)
Clusiaceae 2 (2): *Calophyllum* (1), *Garcinia* (1)
Urticaceae 2 (2): *Boehmeria* (1), *Pilea* (1)
Passifloraceae (2): *Passiflora* (1), *Turnera* (1)
Lauraceae (1): *Persea* (1)
Goodeniaceae 1 (1): *Scaevola* (1)
Sapotaceae 1 (1): *Manilkara* (1)
Thymelaeaceae 1 (1): *Phaleria* (1)
Amaranthaceae 1 (1): *Amaranthus* (1)
Santalaceae 1 (1): *Santalum* (1)
Rosaceae 1 (1): *Rosa* (1)
Basellaceae 1 (1): *Basella* (1)
Apiaceae 1 (1): *Eryngium* (1)
Moringaceae 1 (1): *Moringa* (1)
Bignoniaceae 1 (1): *Mansoa* (1)
Chrysobalanaceae (1): *Atuna* (1)
Gesneriaceae (1): *Chrysothemis* (1)
Polygonaceae (1): *Antigonon*
Caricaceae (1): *Carica* (1)
Vitaceae (1): *Vitis* (1)

MONOCOTYLEDONS (71 species from 46 genera and 15 families)
Arecaceae 17 (20): *Areca* (2), *Rhaphis* (2), *Saba*l (2), *Pritchardia* (1), *Chrysalidocarpus* (1), *Ptychosperma* (1), *Bactris* (1) *Caryota* (1), *Cocos* (1), *Livistona* (1), *Licuala* (1), *Pelagodoxa* (1), *Acrocomia* (1), *Metroxylon* (1), *Pinanga* (1), *Bismarckia* (1), *Bactris* (1), *Veitchia* (1)
Araceae 10 (14): *Alocasia* (2), *Epipremnum* (2), *Philodendron* (2), *Xanthosoma* (2), *Colocasia* (1), *Anthurium* (1), *Syngonium* (1), *Aglaonema* (1), *Monstera* (1), *Spathiphyllum* (1)
Heliconiaceae 1 (10): *Heliconia* (10)
Zingiberaceae 3 (6): *Alpinia* (2), *Hedychium* (2), *Zingibe*r (2)
Marantaceae 1 (3): *Calathea* (3)
Musaceae 1 (4): *Musa* (4)
Pandanaceae 1 (2): *Pandanus* (2)
Costaceae 2 (2): *Cheilocostus* (1), *Costus* (1)
Poaceae 2 (2): *Bambusa* (1) *Saccharum* (1)
Commelinaceae 2 (2): *Commelina* (1), *Tradescantia* (1)
Agavaceae 1 (1): *Cordyline* (1)
Iridaceae 1 (1): *Trimezia* (1)
Dioscoreaceae 1 (1): *Dioscorea* (1)
Cannaceae 1 (1): *Canna* (1)
Asparagaceae 1 (1): *Dracaena* (1)

The severity of impacts of the ant-mealybug juggernaut is clearly variable over space and time, with some localities, individual gardens and different plant species, genera or families more seriously affected than others. Whereas some plants are infested with thousands of ants, mealybugs and other sap-sucking insects, others show only low, limited or incidental presence or no evidence at all of infestation or damage. Other plants have clearly been invaded by ants, but with little clear evidence yet of other insect or pathogens. On infested plants, ants can be seen around the bases of the plants and in a steady streams moving up and down the trunks, branches or stems, something that can be quite dramatic when seen against the lighter coloured bark of trees such as *vesi*, Fiji's national tree *(Intsia bijuga)*(Fig. 11).

Fig. 11. Borneo teak, **vesi** *(Intsia bijuga)*, Fiji's national tree, infested by white-footed ants (WFA)(*Technomyrmex* sp.) on the bark (left) and tending Seychelles scale *(Icerya seychellarum)* on the leaves (right), both USP Lower Campus, Suva, May 2017.

Also seen occasionally on infested plants are other insects that as known predators or parasites of mealybugs, such as the mealybug ladybird, also known mealybug destroyer *(Cryptolaemus montrouzieri)*, an endemic species from Australia that was introduced into the US mainland, Hawai'i and New Zealand over 100 years ago and into Fiji, Vanuatu, Solomon Islands, the Cook Islands and other Pacific Islands prior to WW II, in all cases to control mealybugs and scale insect infestations (Bugs for Bugs 2015b; Martin 2016).

Factors responsible for the variable infestation levels seem to include:

1. Plant form or types, with ferns being virtually unaffected, none of the common gymnosperms, apart from cycads, being infested, and trees, shrubs, lianas and woody plants being preferred hosts over smaller herbaceous species, with virtually no grasses (Poaceae) or sedges (Cyperaceae) being affected;

2. Plant origin and cultivar diversity within a given species, with species and cultivars from, or developed in, Africa or Asia, such as the "Malaysia Dwarf" coconut, showing more resistance than species or cultivars from other regions, such as tropical America, or island endemic plant or traditional Pacific Island food plant cultivars that evolved or were selected in the absence of these IAS of mainly Asian or Australasian origin;

3. Whether a plant is deciduous, drops its leaves and regrows them again after the infestation subsides, e.g. *Terminalia catappa* and *Erythrina variegata;*

4. Mixed planting and intercropping with resistant, aromatic or insect repellent plants;

5. Opportunistic or residual presence of natural and introduced predators or parasites (enemies) of mealybugs, such as ladybirds and the mealybug destroyer ;and

6. Garden or compound cleanliness and frequency and intensity of fumigation or use of pesticides or other less toxic control measures, such as misting oils that serve to control both the mealybug and/or ant populations and consequently the spread and level of mealybug infestation,

The degree of infestation may also vary seasonally and with the weather, with infestation being more virulent during warmer months or during dry spells, something that is supported by the tendency of the PHM to hibernate or hide during the cold season in colder climates, such as in Florida, and remerging when plants have new growth and are in flower or with fruit (Meyerdirk et al. 2001). This has been supported by studies in the early 2000s showing positive correlation between temperature and humidity and dew point and the population density of SS on the host plant *Dodonaea viscosa* in Egypt (Mesbah et al. 2012).

4.1 Ferns

As stressed above, checking most of the common ferns found in the study sites (e.g. *Microsorum, Davallia, Pteris* spp. and the tree fern, **balabala** *(Cyathea lunalata)*, only one fern, a black-stiped edible fern, **ota loa** *(Tectaria latifolia)* was seen with a low or incidental level of infestation.

4.2 Gymnosperms

Although, none of the common larger indigenous gymnosperms (e.g. *Agathis, Dacrycarpus, Dacrydium, Retrophyllym and Podocarpus* spp.) and introduced gymnosperms (e.g. *Araucaria, Cupressus, Pinus and Thuja,* spp.) showed any signs of infestation in any of the study sites, among the most heavily infested of all taxa were cycads, including the indigenous queen sago palm or cycad, **logologo** *(Cycas seemannii)* and king or Japanese sago palm (C. revoluta)(Fig.13), with fronds becoming very chlorotic or dying (Fig. 12). All were infested with varying combinations of Seychelles scale (SS), coconut mealybug (CMB), coffee brown scale (CBS) and Asian cycad scale (ACS) (Table 2, Appendix II).

Fig. 12. Queen cycad, **logologo** *(Cycas seemannii)* plant with dead fronds (left) and underside of a frond infested with Seychelles scale (SS) *(Icerya seychellarum)* and with coffee brown scale *(Saessetia coffeae)* tended by white-footed ants (Technomyrmex sp.)(right), both Nailuva Rd., Suva, June 2017.

Fig. 13. Japanese or king cycad *(Cycas revoluta)* with dead fronds, USP Upper Campus (left); and undersides of fronds infested with both San Jose scale (SJS) *(Quadraspidiotus perniciosus)*(light with nuclear dark-brown central spot) and coffee brown scale *(Saessetia coffeae)*, all tended by white-footed ants (*Technomyrmex* sp.) (right), both Nailuva Rd., Suva, June 2017.

The vulnerability of cycads to scale insects is strongly supported by evidence from both Florida and Guam, where the rampant spread of the recently introduced cycad scale insect (CSI) *(Aulacaspis yasumatsui)*, which is possibly native from Thailand to S. China, devastated cycad populations. In Florida, where CSI was first found in 1996, both *C. revoluta* and *C. seemannii* were heavily infested, as were extensive ornamental plantings of other cycads, including irreplaceable collections in Florida's Fairchild Tropical Garden and Montgomery Botanical Centre, both of which have important world collections of cycads, including rare and endangered species that were threatened by the scale, which also posed an additional threat to the large concentration of nurseries in southern Florida that grow and ship cycads throughout the US and internationally (Weissling and Howard 2017). More recently, in 2003, CSI was discovered and spread rapidly throughout Guam, infesting both horticultural cycads and the endemic cycad, *Cycas micronesica* - a culturally iconic dominant forest and savanna plant. Like many island endemics, *C. micronesica* was particularly susceptible to cycad scale insect, with 100% mortality in infested areas, with the rapid spread threatening the entire population of 1.5 million trees (Campbell 2005; Moore et al. 2005).

4.3 Dicotyledons

Of the 47 infested dicotyledons families, along with the genera and species affected, shown in Tables 3 and 4 and Appendices I and II, the 22 most seriously affected families, in approximate order based of severity of infestation of individual species, numbers of species affected, levels of infestation, damage to plants and the cultural, economic and environmental costs represented by their loss, are:

Rutaceae (Citrus or Rue Family): All of Fiji's important citrus trees (*Citrus* spp.)(Fig. 14) and island musk *(Euodia hortensis)* (Fig. 15) are seriously infested, almost exclusively by SS, with many also heavily infested with black sooty mould (BSM), which may be an indication that the more competitive SS has replaced citrus mealybug (CTM) and other species known to infest *Citrus* spp.

Fig. 14ab. Pommelo, **moli kana** *(Citrus maxima)*, an important threatened multipurpose Fijian cultural plant infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Borron Rd., Suva, August 2017.

Fig. 15. Island musk, uci *(Euodia hortensis)*, a native sacred Fijian plant, the leaves and flowers of which are used medicinally, in garlands **(salusalu)** and to perfume coconut oil, the underside of the leaves and stems of which are infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), National Trust of Fiji, May 2017.

Moraceae (Mulberry or Fig Family): Important food and multipurpose plants that are infected include, breadfruit, **uto** *(Artocarpus altilis)*(Fig. 16), an important seasonal staple food and multipurpose plant; jackfruit, **uto ni Idia or katthar** *(Artocarpus heterophyllus)*, an important Indian staple food and; paper mulberry *(Broussonetia papyrifera)*(Fig; 17), an important women's crop that is used for making tapa (bark) cloth. Also infested, mainly by SS, are a wide range of culturally important indigenous and introduced figs and banyan trees (*Ficus* spp.), with the universally most highly infested species being the Fijian endemic figs, Barclay's fig, losilosi *(F. barclayana)*(Fig. 18), which is also seen infested with citrus mealy bug (CTM), and Fiji fig, lolō *(F. vitiensis)* (Fig 19).

Fig. 16. Breadfruit, **uto** *(Artocarpus altilis)*, an important staple food crop and multipurpose tree, the undersides of the leaves which are infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Laucala Bay Rd. Suva, June 2017.

Fig. 17. Paper mulberry, **masi** *(Brousonnetia papyrifera)*, an important handicraft plant, the inner bark or bast fibre of which is used to make tapa cloth **(masi)**, with the leaves (left) and stems (right) infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Laucala Beach Estate, Suva, June 2017.

Fig. 18. Barclay's fig, **losilosi** *(Ficus barclayana)*, an important endemic Fijian medicinal plant, infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Nailuva Rd. (left) and Knolly St., Suva (right), May 2017.

Fig. 19. Fiji fig, **lolō** *(Ficus vitiensis)*, an important endemic Fijian medicinal plant, emergency food plant and fruit bat and bird food, infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (Technomyrmex sp.), Nailuva Rd., Suva, August 2017.

Malvaceae (Mallow or Hibiscus Family): A wide range of ornamental hibiscus (*Hibiscus* spp. and hybrid cultivars)(Figs. 20 and 21) and the culturally important multipurpose plant, beach hibiscus *(Hibiscus tiliaceus)*(Fig. 22), are seriously affected by pink hibiscus mealybug (PHM), which infests the growing tips causing the infested plants to become stunted, leading to "bunchytop", with the flowers either not forming, drying up or remaining in a stunted or shrivelled state or dropping off.

Fig. 20. Common hibiscus, **senitoa** *(Hibiscus rosa-sinensis)* with the terminal buds and immature shrivelled flowers infested with pink hibiscus mealybugs *(Maconellicoccus hirsutus)* tended by pink hibiscus mealybugs *(Maconellicoccus hirsutus)*, Governors Museum Themed Restaurant, Suva, May, 2017.

Fig. 21. Hybrid hibiscus with the Fiji endemic, Storke's hibiscus *(Hibiscus x storkei)*, the dying stunted flowers and growing tips of which are infested with pink hibiscus mealybugs *(Maconellicoccus hirsutus)* tended USP Lower Campus, Suva, May, 2017.

Figure 22. Beach hibiscus, **vau** *(Hibiscus tiliaceus)* leaves infested with pink hibiscus mealybugs *(Maconellicoccus hirsutus)*, Oceania Centre for Arts and Culture, USP, Suva, August 2017 (left above and below); and a young beach hibiscus trunk infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp), Nailuva Rd., Suva, Fiji, May 2017.

Also affected, but mainly by SS, are okra, roselle and hibiscus spinach or **bele** (*Abelmoschus* spp.); and the important cultural medicinal and woodcarving plant, Thespian's tree, **mulomulo** *(Thespesia populnea)* is also affected by SS, citrus mealybug (CTM), and possibly by PHM. The weedy species, Pink hibiscus bur *(Urena lobata)*, was infested with SS, what appears to be nigra scale (NS) and white fly (SWF). Bele (Ablelmoschus manihot) is also seriously affected by the *Abelmoschus* shoot borer (ASB) *(Earias vittella)*;

Fabaceae (Legume, Bean or Pea Family): Also infected are also important leguminous food plants (*Vigna, Phaseolus, Psophocarpus* and *Inocarpus* spp.)(Fig. 23), nitrogen-fixing legumes (*Flemingia, Centrosoma, Vigna* and *Calliandra* spp.), ornamental species (*Albizia, Bauhinia, Cassia, Samanea* and *Senna* spp.)(Fig. 24) and Fiji's culturally important national tree, **vesi** *(Intsia bijuga)*, are all infested at variable levels by SS, with Bauhinia and *Cassia* spp., also infested with black sooty mould (BSM).

Fig. 23. French beans *(Phaseolus vulgaris)* leaves (left), Laucala Beach Estate (left) and longbeans *(Vigna sesquidpedalis)* stems and fruit, Flagstaff (right), both infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (WFA), Suva, July 2017.

Fig. 24. Golden shower tree, **vaivai** *(Cassia fistula)* leaves infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (WFA) (*Technomyrmex* sp.), USP Upper Campus, Suva, August 2017 (upper and lower left), showing flowers of unaffected tree (right).

Myrtaceae (Myrtle Family): A wide range of culturally useful food and multipurpose plants (*Syzygium* spp.) and guavas (*Psidium* spp.), particularly common guava *(P. guajava)* (Fig. 25), are seriously infested by SS, coconut mealy bug (CMB), spiralling whitefly (SWF) and black sooty mould (BSM), with some cherry guava *(P. cattleyanum)*, also infested with SS and SWF. Also heavily infested with SS were pomegranate *(Punica granatum)* and **leba** *(Syzygium neurocalyx)*(Fig. 26), a threatened Fijian medicinal and garland plant.

Fig. 25. Guava, **quwawa** *(Psidium guava)* leaves infested with coconut mealybugs *(Nipaecoccus nipae)*, Nasese, Suva, June, 2017 (left); and infested with both citrus mealybug *(Planococcus citri)* and spiralling whitefly *(Aleurodiscus dispersus)*, Beachhouse Resort, Nadroga May 2017 (right), both tended by white-footed ants (Technomyrmex sp.)

Fig. 26. **Leba** *(Syzygium neurocalyx)*, a rare endemic sacred Fiji plant, the fruit of which is used to make garlands **(salusalu)**(left) and the underside (right) of a leaf infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Laucala Beach Estate, Suva, Fiji, May 2017.

Annonaceae (Custard Apple Family): Soursop (Fig. 27) sweetsop and bullock's heart (Fig.4 , above) (*Annona* spp.), ylangylang or perfume tree *(Cananga odorata)* (Fig. 28), and trees of cultural importance to both Fijian and Indian people, **mocelolo** *(Polyalthia laddiana)* and the ashok tree, **ashoka** *(Polyalthia longifolia)* are infested by SS, with soursop and other *Annona* spp. also infested with coconut mealybug (CMB), black sooty mould (BSM) and the fruit of soursop with citrus mealybug (CTM).

Fig. 27. Soursop, **seremaia** *(Annona muricata)* fruits infested with citrus mealybug *(Planococcus citri)* tended by white-footed ants (WFA), on Drew St., Suva, July 2017 (left) and at Legalega Research Station, Nadi, September 2017 (right, closup).

Fig. 28. Ylangylang or perfume tree, **makosoi** *(Cananga odorata)* flowers and leaves, Laucala Beach Estate, Suva, July 2017 (left) and upper stems very heavily infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (WFA), Nailuva Rd., Suva, December 2017 (right).

Rubiaceae (Coffee or Madder Family): Important ornamental plants, the flowers of which are used in garlands, such as gardenias (*Gardenia* spp.) and a range of ixoras (*Ixora* spp.), mussaenda (*Mussaenda* spp.), Indian mulberry or noni *(Morinda citrifolia)*(Fig. 5 above) and coffee (*Coffea* sp.) are all infested with a range of IAS including SS, PHM, CTM and CBS and NS, with the citrus mealybug (CTM) and the coffee brown scale (CBM) and/or nigra scale (NS), always tended by WFA. Black sooty moulds (BSM) also heavily infest most Rubiaceae (Fig. 29). On the positive side, also found on gardenias, ixoras and Indian mulberry were the larvae of the mealybug destroyer (MBD), which seems to be more common in association with citrus mealy bugs (CTM) and scale insets (CBS and NS), which it may have been reduced in numbers before the current invasion.

Fig. 29. Cape jasmine (gardenia), **jiale ni vavalagi** *(Gardenia jasminoides)* infested with citrus mealybug *(Planococcus citri)* tended by white-footed ants, USP Upper Campus, Suva, Sept. 2017 (left) and Tahitian gardenia or **tiare Tahiti** leaves infested with black sooty mould and white-footed ants (Nailuva R., Dec. 2017) (right).

Lauraceae (Laurel Family): Avocado *(Persea americana)* is one of the most heavily and widely infested species, by both SS, CMB and BSM, with many gardeners' mature trees dying due to high levels of infestation (Fig. 30 and Fig. 2 above).

Fig. 30. Avocado, **pea** *(Persea americana)* leaf infested by Seychelles scale *(Icerya seychellarum),* Desvoux Rd., Suva, May 2017 (left) and by coconut mealybug *(Nipaecoccus nipae)*, USP Upper Campus, Sept. 2017 (right), both tended by white-footed ants (*Technomyrmex* sp.),

Euphorbiaceae (Spurge Family): A range of ornamental and culturally useful plants (*Acalypha, Codiaeum, Euphorbia and Macaranga* spp.) are infested, with the common ornamental chenille plant or red-hot poker *(A. hispida)* seriously affected by SS (Fig. 3 above); the common ornamental, *A. wilkesiana* is affected by both SS and SWF; croton (*Codiaeum variegatum,* is affected by both citrus mealybug (CTM)(Fig. 31) and nigra scale (NS); the endemic Fiji spurge *(Euphorbia fidgiana)* is infested with SS; cassava (*Manihot* spp.) (Fig. 6 above) infested with both BCS and SWF; and the native timber tree, whitewood or **kauvula *(Endospermum macrophyllum) is*** the only species seen affected by the longtailed mealybug (LTM) *(Pseudococcus longispinnus)*.

Fig. 31. Croton, **sacasaca** *(Codiaeum variegatum)* infested with citrus mealybugs *(Planococcus citri)* tended by white-footed ants (*Technomyrmex* sp.), USP Laucala Campus, Suva, September 2017.

Goodeniaceae (Goodenia Family): The culturally important multipurpose and coastal protection plant *(Scaevola taccada)* showed very high levels of infestation by SS in Suva (Fig. 32), which is supported by the fact that it was one of the most seriously affected native species on Aldabra Atoll in the Indian Ocean in the 1970-80s (Newbery, 1980; Newbery and Hill 1985).

Fig. 32. Beach half-flower or scaevola, **vevedu** *(Scaevola taccada)*, an important indigenous multipurpose cultural plant and coastal protection species, infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Oceania Centre for Arts and Culture, USP (left) and USP Lower Campus (right), August 2017.

Casuarinaceae (Casuarina Family): Both the endemic Fiji casuarina *(Gymnostoma vitiense)* and common casuarina *(Casuarina equisetifolia)* are infested, the former at high levels.

Fig. 33. Fiji casuarina, **velau** *(Gymnostoma vitiensis)* leaves (left) and stems (right) infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (WFA), USP Lower Campus, Suva, August 2017.

Piperaceae (Pepper Family): Both betel pepper, **paan** *(Piper betle)* (Fig. 34), an important Indian cultural plant the invasive spiked pepperbush *(Piper aduncum)*, a tropical American species, is also often heavily infested with SS, tended by WFA.

Fig. 34. Betel pepper, **paan** *(Piper betle)* the leaves of which are chewed with betelnut by South Indian and Solomon Island residents, infested by Seychelles scale *(Icerya seychellarum) and* tended by white-footed ants (*Technomyrmex* sp.), Nailuva Rd., August 2017.

Solanaceae (Nightshade Family): Eggplant, tomato and other edible and weedy plants, such as chili peppers and capsicums (*Capsicum* spp.) are infested with SS and SWF, the weedy shrub, prickly solanum *(Solanum torvum)* with SS, with eggplant being among the most heavily infested by SS (Fig. 35).

Fig. 35. Eggplant, **baigan** *(Solanum melongena)* leaves (left) and stem (right) infested by Seychelles scale *(Icerya seychellarum)*(left) and tended by white-footed ants (WFA), Fiji National Food and Nutrition Centre, May 2017.

Anacardiaceae (Cashew Family): Mangoes, often depending on the cultivar, can be heavily infested with SS, coconut mealy bug (CMB) and black sooty mould (BSM).

Acanthaceae (Acanthus Family): A range of ornamental plants are infested, mainly at low levels by SS, the most heavily infested species being *Pachystachys* spp., natives to tropical America, and *Hemigraphis alternata*, a common groundcover native to Malaysia that has become a minor invasive in lawns and pot plants.

Convolvulaceae (Morning-glory Family): Sweet Potato and a number of weedy vines (*Ipomoea* and *Merremia* spp) and omemetal plants are infested by SS, with only the woodrose *(M. tuberosa)*, native to Mexico, showing high levels of infestation (Fig. 36).

Fig. 36. Hawaiian woodrose or yellow morning-glory *(Merremia tuberosa)* flower (left) and underside of leaf infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.)(right), USP Botanical Garden, Suva, August 2017.

Lythraceae (Loosestrife Family): Two common ornamental crepe myrtles (*Lagerstroemia* spp.) and Mexican heather *(Cuphea hyssopifolia)*, the latter a Mexican and Central American species, are sometimes heavily infested by SS.

Boraginaceae (Borage or Forget-me-not Family): Indian olive or **lasora** *(Cordia myxa)* is infested with SS and beach cordia, **nawanawa** *(Cordia subcordata)*, is sometimes infested with SS and coffee brown scale (CBC).

Fig. 37. Healthy beach cordia, **nawanawa** *(Cordia subcordata)*(left); fruit stems infested with coffee brown scale *(Saisettia coffaea)* tended by tended by white-footed ants (*Technomyrmex* sp.), USP Lower Campus, August 2017 (right).

Verbenaceae (Verbena or Vervain Family): A range of introduced ornamental species (*Clerodendrum* spp.)(Fig. 38), and the native species, blue vitex *(Vitex trifolia)*, are all infested with low levels of SS and/or CTM.

Fig. 38. Philippine glorybower *(Clerodendrum quadriloculare)* leaf (left) infested with coconut mealybugs *(Nipaecoccus nipae)*; and flowers (right) infested with citrus mealybugs *(Planococcus citri)*, both tended by white-footed ants (*Technomyrmex* sp.), USP Laucala Campus, Suva, September 2017.

Lamiaceae (Mint Family): Basils (*Ocimum* spp,), particularly holy or sacred basil *(O. tenuiflorum)*, and teak *(Tectona grandis)*, an important plantation timber tree, the common ornamental climber, and woolly congea or shower orchid *(Congea tomentosa)*(Fig. 39), are all infested with SS, with basils sometimes also infested with spiralling white fly (SWF).

Fig. 39. Wooly congea or shower orchid *(Congea tomentosa)* flower (left) and leaf infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.)(right), Beachhouse Resort, Nadroga, Fiji, May 2017.

Apocynaceae (Dogbane Family): Frangipanis or plumerias (*Plumeria* spp.) are infested with SS, CTM, plumeria rust (PR) and black sooty mould (BSM) (Fig; 10 above); and maile, **vono** *(Alyxia stellata)*, an important native Fijian cultural plant used for sacred garlands throughout the Pacific was also seen heavily infested with SS (Fig 40).

Fig. 40. Maile, **vono** *(Alyxia stellata)* stem and leaves (left) and close-up of stem (right), heavily infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Laucala Beach Estate, Suva, July 2017.

Cucurbitaceae (Gourd or Cucurbit Family): Infested species include ridged gourd, **taroi** *(Luffa acutangula)*, pumpkin *(Cucurbita moschatus)* and cucumber *(Cucumis sativus)*, which are mainly infested with low levels of SS, but also widely affected by downy mildew fungal diseases and viral infections, some of which do not seem to be ant-related.

Sapindaceae (Soapberry Family): fernleaf tree *(Filicium decipiens)*, Japanese maple *(Acer palmatum)* and oceanic lichi, **dawa** *(Pometia pinnata)* are infested with SS.

Other dicotyledons families with species infested at mostly low levels are shown in Table 4 and Appendices I and II. Of these, species most commonly infested include: the Tongan national tree or flower, **heilala** *(Garcinia sessilis)*(Clusiaceae), a tree native to Fiji and apparently an aboriginal introduction into Tonga: carambola (*Averrhoa carambola* (Oxalidaceae); Mascarene Islands leaflower *(Phyllanthus tenellus)* (Phyllanthaceae); damask rose (*Rosa* x *damascena*); and **sinu ni baravi** or **mataivi** *(Phaleria disperma)* (Thymeliaceae), an important Fijian cultural plant.

4.4 Monocotyledons

Of the 14 infested dicotyledons families, along with the genera and species listed in Table 4 and Appendices I and II, the 5 most seriously affected families in approximate order degree of infestation based on a combination of numbers of species affected, levels of infestation, damage to plants and the cultural, economic and environmental costs represented by their loss, along with mention of some of the important species most seriously affected are:

Arecaceae (Palm Family): At least 21 palm species were affected, the most widely infested including the coconut palm (Fig. 41), betelnut palms *(Areca catechu)*, Bismarck palm *(Bismarckia nobilis)* (Fig. 42), fishtail palm *(Caryota urens)*, golden cane palm *(Chrysalidocarpus lutescens)*, ruffled fan palm *(Licuala grandis)*, Macarthur palm *(Ptychosperma macarthuri)*, bush palmetto *(Sabal minor)* and the indigenous or aboriginally introduced Fiji or Pacific fan palm *(Pritchardia pacifica)* and a wide range of introduced ornamental palms, most of which are infested with coconut mealybug (CMB) and/or Seychelles scale (SS), with many species also infested with black sooty mould (BSM).

Fig. 41. Coconut palm, **niu** *(Cocos nucifera)* with flower spathes and fruit infested by coconut mealy bug *(Nipaecoccus nipae)* tended by white-footed ants (*Technomyrmex* sp.), Muanikau, Suva, Sept. 2017.

Fig. 42. Young Bismarck palm *(Bismarckia nobilis)*(left) and underside of leaf infested by coconut mealy bug *(Nipaecoccus nipae)* tended by white-footed ants (WFA), USP Botanical Garden, July 2017.

Fig. 43. Golden cane palm *(Chrysalidocarpus lutescens)* flower spathes infested by Seychelles scale *(Icerya seychellarum)*, Tamavua, Suva, August 2017 (left) and Chinese fan palm *(Livistona chinensis)* frond infested with coconut mealybug *(Nipaecoccus nipae)*, USP Botanical Upper Campus, Suva, September 2017 (right), in both cases tended by white-footed ants (WFA)(*Technomyrmex* sp.).

Araceae (Arum of Taro Family): The 14 infested Araceae species included the indigenous forest vine, **yalu** *(Epipremnum pinnatum)*; a number of introduced ornamental species, including anthuriums (Fig. 44), philodendrons (*Philodendron* spp., and cultivars), arrowhead vine *(Syngonium podophyllum)* and *Aglaonema* spp. which are infested with SS and/or CMB; and important food plants taro, **dalo** *(Colocasia esculenta)*, and American taro or tannia **(dalo ni tana)** and belembe or tanier spinach (*Xanthosoma* spp.), which are infested with SS and/or aphids.

Fig. 44. Anthurium or flamingo flower *(Anthurium andraeanum)* (left) and underside of leaves (right) infested by Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (WFA), Vatuwaqa, Suva, July 2017.

Heliconiaceae (Heliconia Family): At least 9 species or hybrid cultivars of heliconia (*Heliconia* spp. and cultivars), almost all native to tropical America, were infested, many at medium to high levels, with coconut mealybug (CMS) and/or SS tended by WFA (Figs 45 and 46).

Fig. 45. Parakeet or golden torch heliconia cultivar *(Heliconia psittacorum)* flower (left) and underside of leaf infested with coconut mealybug *(Nipaecoccus nipae)* tended by white-footed ants (*Technomyrmex* sp.), Nasese, Suva, July 2017 (right).

Fig. 46. Lobster claw heliconia *(Heliconia rostrata)* flower infested with coconut mealybug *(Nipaecoccus nipae)* (left) and underside of leaf infested with Seychelles scale *(Icerya seychellarum)*, both tended by white-footed ants (*Technomyrmex* sp.), Nailuva Rd., Suva, December 2017.

Zingiberaceae (Ginger Family): Some 6 species are infested, the most commonly infested of which are red ginger and variegated gingers (*Alpinia* spp.) and white and pink gingers (*Hedychium* spp.), which are infested with SS and/or CMB, with some species also infested with aphids.

Fig. 47. Red ginger, **cevuga damu** *(Alpinia purpurata)* infested with Seychelles scale *(Icerya seychellarum)* tended by white-footed ants (*Technomyrmex* sp.), Rifle Range, Suva, July 2017 (left) and variegated ginger *(Alpinia vittata)* infested with white-footed ants, Nailuva Rd., Suva, August 2017 (right).

Poaceae (Grass Family): Although members of the grass family were uncommonly infested, bamboo was seen to be infested by the soft bamboo scale *(Bambusapis bambusae)* tended by WFA and sugarcane was seen infested WFA (Fig. 48) and, at times, with citrus mealybug (CTM) *(Planococcus citri)*

Fig. 48. Common giant bamboo, **bitu ni vavalagi** *(Bambusa vulgaris)* infested with soft bamboo scale *(Bambusaspis bambusae)* tended by white-footed ants (*Technomyrmex* sp.), USP Upper Campus, September 2017 (left) and sugarcane, dovu *(Sacchraum officinarum)* was seen infested by WFA tending their eggs (USP Upper Campus, Sept. 2017).

Marantaceae (Arrowroot Family): Ornamental species infested with CMB and/or SS include rattlesnake plant *(Calathea crotalifera)* and other *Calathea* spp.

Other infested monocotyledons families that have a number of species infested at mostly low levels are listed in Table 2 and Appendices I and II).

4.5 Non-infested Species

Common species and families of mainly woody plants that were never, or rarely, seen infested during the Fiji WFA-Mealybug Invasion are listed in Table 5 and in more detail in Appendix IV, along with common and Fijian names, origins and characteristics of the plants that may help to explain their resistance to infestation. Factors that may be responsible for their apparent resistance to the Ant-Mealybug Invasion could include that these species are:

1. Native to Africa, the Indian Ocean or South Asia, the apparent source areas of WFA, SSS, HMB, CMB and many other sap-sucking insects, where they have possibly co-evolved with and developed resistance to these invasive species;

2. Toxic or medicinal plants, the sap of which is milky or latex-like and unattractive or toxic to, or that do not produce honeydew targeted by, mealybugs, scales and other sap-sucking insects;

3. Widespread Indo-Pacific coastal species that have in-built resistance to the infestations;

4. Highly aromatic species that repel IAS; and

5. Resistant species widely used as ornamental or hedges or groundcovers, that appear to be poisonous, unattractive to ants and mealybugs or have high resistance to infestation.

Table 5. Families and species of native and introduced, mainly woody plant species that are unaffected or almost never affected by the WFA-mealybug and sap-sucking insect bio-invasion in Fiji, based on field studies by R. Thaman from May—September 2017 (Notes: 1) * = common species showing very limited or incidental infestation in only one or few locations, but uninfected in almost all study sites; 2) see Appendix IV for details of common and Fijian names, origin, characteristics of plants that may help to explain their resistance to infestation, and main sources of information.)

Euphorbiaceae (11): **Aleurites moluccana, Breynia disticha, *Bischofia javanica, Euphorbia cotinifolia, *Excoecaria agallocha, Glochidion concolor, Jatropha curcas, J. integerrima, Pedilanthes tithymaloides, Leucaena leucocephala, *Millettia pinnata*

Verbenacee (6): *Citharexylum spinosum, Clerodendrum inerme, *Clerodendrum thomsonae, *Duranta erecta, Lantana camara, Premna serratifolia*

Apocynaceae (5): *Allamanda cathartica, Cascabela thevetia, Catharanthus roseus, Cerbera manghas, Nerium oleander, Tabernaemontana divaricata*

Araliaceae (5): **Polyscias filicifolia, P. fruticosa, *P. guilfoylei, *P. scuttelaria, Schefflera actinophylla, S. arboricola*

Meliaceae (4): *Azadirachta indica, Melia azedarach, Swietenia macrophylla, Xylocarpus granatum*

Asparagaceae (3): *Dracaena angustifolia, D. fragrans, D. marginata*

Lamiaceae (2): *Plectranthus amboinicus, P. scutellarioides*

Moraceae (2): *Ficus benjamina, F. elastica*

Myrtaceae (2): *Pimenta racemosa, *Syzygium malaccense*

Poaceae (2): *Bambusa multiplex, *B. vulgaris*

Acanthaceae (1): *Thunbergia erecta*

Asclepiadaceae (1): *Calotropis gigantea*

Asteraceae (1): *Sphagneticola trilobata*

Hernandiaceae (1): *Hernandia nymphaeifolia*

Nyctaginaceae (1): *Bougainvillea* spp.

Piperaceae (1): *Piper methysticum*

Solanaceae (1): **Cestrum nocturnum,*

Araceae (1): *Dieffenbachia seguine*

Strelitziaceae (1): *Ravenala madagascariensis*

Some of the more common un-infested or rarely-infested species (Appendix III) include:

- Plants native to Madagascar or Africa: poinciana or flame tree *(Delonix regia)*, a common ornamental and street; traveller's palm *(Ravenala madagascariensis)*; and Madagascar periwinkle *(Catharanthus roseus)*, an ornamental and medicinal plant with poisonous properties (all three native to Madagascar); and bleeding heart *(Clerodendrum thomsonae)*, a medicinal plant from tropical West Africa.

- Plants native to India, South Asia or Australasia: neem tree *(Azadirachta indica)*, an important medicinal plant renowned for its use as an organic insecticide and insect repellent; crape jasmine, false gardenia or **chameli** *(Tabernaemontana divaricata)*, a medicinal plant with milky sap sacred to Hindus; bush thunbergia *(Thunbergia erecta)*; crown flower *(Calotropis gigantea)*, a plant with poisonous milky sap; two banyan or fig trees, weeping banyan and the Indian rubber tree (*Ficus benjamina* and *F. elastica*); and Queensland umbrella tree *(Schefflera actinophylla)*, an invasive species in Fiji, which is native from Indonesia to New Guinea and N. Australia, and dwarf Schefflera (S. arboricola), which is native to Taiwan.

- Plants of tropical or subtropical American or other origin: gliricidia or mother-of-cocoa *(Gliricidia sepium)*, the seeds and bark of which are poisonous to rats and mice; leucaena or lead tree, **vaivai ni vavalagi** *(Leucaena leucocephala)*, an introduced nitrogen-fixing and very invasive legume that contains mimosine, an amino acid toxic to ruminants; a range of euphorbs, including red spurge *(Euphorbia cotinifolia)*, physic nut *(Jatropha curcas)*, rose-coloured jatropha *(J. Integerrima)* and redbird cactus or slipper flower *(Pedilanthes tithymaloides)*, all of which have poisonous milky sap; bougainvillea (*Bougainvillea* spp.), an important medicinal plant in South America; bigleaf or West Indian mahogany *(Swietenia macrophylla)*, a medicinal plant with strong tannins; night-blooming cestrum, **caucaunibogi** *(Cestrum nocturnum)* with poisonous fruit; and yellow oleander or be-still tree *(Cascabela thevetia)* and oleander *(Nerium oleander)* (a native Mediterranean shrub), both with extremely poisonous milky sap that can be lethal to humans if ingested.

- Widespread Indo-Pacific coastal or mangrove-associated species: beach walnut or pongam *(Millettia pinnata)*, an important Fijian medicinal plant; sea mango *(Cerbera manghas)* and fish poison vine *(Derris trifoliata)*, both almost universally used to poison fish in the Pacific Islands; beach elderberry *(Premna serratifolia)*, a very important medicinal plant; cannonball tree *(Xylocarpus granatum)*, a mangrove species used medicinally; Oriental or brown mangrove, **dogo** *(Bruguiera gymnorrhiza)* and red mangrove and mucronate or spotted mangrove, both **tiri** *(Rhizophora spp)*, all important medicinal plants and sources of tannin; Chinese lantern tree, **eveuevu** *(Hernandia nymphaeifolia)*, an important medicinal plant.

- Uninfested highly aromatic or toxic beverage plants or plants used to protect gardens from evil spirits include kava yaqona (Piper methysticum), the important Pacific mild narcotic social beverages and medicinal plant; Indian borage and variegated coleus, (*Plectranthus amboinicus* and *P. scutellarioides*) and bayrum tree, **sinamoni** *(Pimenta racemosa)*, an important medicinal plant

- Common uninfested hedge or ornamental plants include: wedelia or trailing daisy *(Sphagneticola trilobata)*, a widely planted groundcover from tropical America that has escaped from cultivation and is reportedly toxic to goats; four species of slightly aromatic hedge panaxes (*Polyscias* spp.), all native to S. E. Asia or Western Melanesia; a range of dracaenas or dragon flowers (*Dracaena angustifolia, D. Fragrans, D. marginata* and *D. sanderiana*), all reportedly native to tropical West Africa or to Asia and possibly Australia and Melanesia, in the case of *D. angustifolia*; leaf-flower of the Pacific Islands *(Breynia disticha)*; and golden dewdrops *(Duranta erecta)* and lantana *(Lantana camara)*, both poisonous, the latter of which is a serious invasive species (Appendix III).

5 CAUSES AND TIMING OF THE FIJI ANT-MEALYBUG BIOINVASION

Like "climate change" and "natural disasters" and most other tragedies, the 2016 Fiji Ant-Mealybug Bio-invasion is probably multi-causal with multiple direct and indirect drivers contributing to a breakdown in resilience of the local socio-ecological ecosystems, in this case creating serous negative synergies that are responsible for the success and extent of the invasion. First and foremost, however, is that the current bio-invasion is clearly multi-pronged and based on the rise to super-abundance of WFA and the strong symbiotic relationships that it has with Seychelles scale (SS), pink hibiscus mealybug (PHM), coconut mealy bug (CMB), citrus mealybug (CTM), other mealybugs or scale insects, whiteflies, aphids and other insect pests and fungal diseases. Without the rise to superabundance of WFA, it is doubtful if the invasion would be as serious. Among the possible contributing factors to the seriousness of the bio-invasion include:

1. Possible recent introduction of more virulent genetic strains of SS and/or the recent introduction, spread and population explosion of the WFA, which has replaced the less competitive and productive *Technomyrmex albipes* and other previously common ants such as the longhorn crazy ant *(Paratrechina longicornis)*, a slightly larger, faster-moving ant than the WFA that emits a slight fruity odour when crushed and which seemed to be the dominant ant in our households and kitchens two or three years ago (Wetterer 2008; Warner and Scheffrhan 2016). This which is supported by a listing all of the ants in association with pineapple mealy bugs throughout the world (including South Africa, South and Central America, the Caribbean, Malaysia, Philippines, Australia Hawaii, and Fiji), which included most of the well-known tramps ants (e.g., *Pheidole, Camponotus, Crematogaster, Linepithema, Tetromorium Tapinoma, Paratrechina, Solenopsis, Wasmannia* spp.), but **did not** list WFA from any location in association with mealybugs, except South Africa (El Wanis (John 1990; E Wanis c.2010).

2. Possible introduction or reintroduction of the ants and/or SS along with relief supplies in the aftermath of Tropical Cyclone Winston (TCW), the strongest cyclone ever affecting Fiji on 20 February 2016.

3. The highly invasive SS has been a relatively recent re-introduction into Fiji where there are no natural enemies or where introduced predators and parasites were in insufficient numbers to deal with the invasion, possibly due to the indiscriminate use of insecticides that have led to a pest backlash in the absence of predators (Thaman 1984). This is supported by reports that recent outbreaks of tea scale *(Fiorinia theae)* that threaten the tea industry in Assam, India may be due to over-dependence on synthetic pyrethroid insecticides that may have been responsible for reducing predator populations (Staff reporter 2017), something supported by mealybug and scale expert, Gillian Watson (2017 pers. Com.)

4. The possible, eradication or reduction to extremely low levels of the natural predators, parasites and diseases that suppress mealybugs after TCW, which according to Watson (2017 pers. Com.), a renowned authority on mealybugs and scale insects, is known to happen periodically when violent storms hit small islands.

6 CONTROL OF THE WFA– MEALYBUGS BIOINVASION

As most people in Fiji know too well, the control of WFA, and more recently the additional challenge of controlling mealybugs, scale insects and other ant-associated insects and diseases, is extremely difficult and, until now, has largely required the almost continuous and vigilant use of costly and dangerous insecticides (reportedly mainly easy-to-buy, but expensive spray-cans of Mortein™, Raid™, etc., in urban areas) and the use of baits placed along trails and in areas of infestation to control WFA. In terms of the use of less toxic substances, some people have had success using a combination of borax, mixed with sugar or honey, or other mixtures, such as turmeric and oil left in saucers in ant-infested areas or pouring soapy dish water or vinegar on infestations; and continually cleaning food preparation areas, cupboards and ant nesting areas in garages, washrooms and waste areas around buildings and homes and in gardens to control ants.

Long-term control, not to mention "eradication" of the species involved in the 2016 Fiji Ant-Mealybug Bioinvasion will, however, be extremely difficult and require integrated pest management and the combination of a range of cultural and chemical controls and, in the long-term, probably biological control agents. This is due to: 1) the multi-species nature of the invasion and the strong symbiotic relationships that WFA have with mealybugs, scales and other infesting organisms; 2) the extent of the invasion, the large size of ant colonies, and the high reproductive rates, mobility and dispersal ability of these invasive organisms; 3) the high diversity of suitable habitats and host plants and plant parts that are infested; 4) their ability to hide in cracks, crevices, tree bark, etc. which protects them from both natural enemies and humans control, including the protection from insecticides and other control agents afforded to mealybugs and scales by their natural coatings of waxy egg sacs and hard scale-like, structures (which are reportedly almost impossible to penetrate with many pesticides) with the last resort and possibly most sustainable long-term option being the use of biological control agents (McKenzie 1967; Meyerdirk et al. 2001; Bugwood 2003; Mesbah et al. 2009; Mani 2016).

As stressed in Jamaica, because of the close relationship between WFA and SS mealybugs and scale insects, the control of WFA is key to the successful containment of the insects that the ants tend and protect from natural and introduced predators, parasites and diseases (JIS 2007), which without the ants, both natural and introduced predators and pathogens can help control the mealybugs and other insects (Jackson 2015). This is borne out in Fiji by the fact that some of the only areas found largely free of both pests are those, such as tourist resorts, hotel, restaurants and other institutions, that routinely, in some cases almost daily, spray insecticides to rid their properties, including their gardens and landscaping, from bothersome and off-putting (to tourists and diners) ants, cockroaches, flies, mosquitos and bedbugs, thus inadvertently also controlling WFA, mealy bugs and other associated insects and resultant fungi or sooty moulds.

6.1 Cultural Controls

Cultural controls include:

6.1.1 Removal or destruction of ant nests and nesting sites: The removal or destruction of outdoor and indoor ant nests and potential nesting sites, such as woodpiles, rubbish or waste accumulations, or by burning or the use of boiling water to destroy ant nests, and continual cleaning of cupboards and ant nesting areas in garages, washrooms and waste areas around buildings and homes and in gardens is the first step to controlling WFAs.

6.1.2 Use of adhesives, sticky tapes and banding: By banding the lower trunks or stems of plants or placing or painting adhesives pastes, strong-smelling substances such as turmeric paste or other products (some of which are sold to intercept and/or kill rats, cockroaches and other pests) on cardboard or small pieces of wood, to catch or impede the movement of ants, is a technique that has been used successfully by some people in Suva to stem the flow and reduce populations of WFA on their properties.

6.1.3 Physical removal: Hand removal or wiping or spraying jets of water or misting oils (e.g. white oil™) to physically remove mealybugs, scales and other insects from plants has, when combined with other interventions, has also helped control the level of infestation.

6.1.4 Weed control and removal, destruction and control of movement of infested plant materials: One of the most sustainable, long-term ways of controlling the WFA-mealybug invasion is the control of weeds and removal, disposal and destruction or burning of infested plants and plant materials (e.g., cuttings, flowers and fruits) to ensure the removal and destruction of the white egg sacks and pink mealybugs. This would include pruning of infested lower branches to stop ants from reaching and infesting other parts of the plant. Because immature mealybugs move on wind currents, it is important, where feasible to burn infested material or to place suspected infested materials into sealed plastic bags for transport because the movement of materials in open vehicles is particularly risky, because of the virulence of mealybug infestations, under a Pink Hibiscus Mealy Bug Order of 2007, Jamaica mounted an awareness campaign and strictly prohibited the movement of any plants, seedlings, cuttings or plant products or material into or out of affected areas (RJR News 2007); and the Jamaica Ministry of Agriculture and Lands established a “Mealy Bug Hotline” that people were to phone when they experienced an infestation so that authorities could visit and assess the infestation; and because of the virulence of the infestation, the Rural Agricultural Development Agency (RADA) did not want farmers to take samples which could further contribute to the spread of this pest. It was stressed that when farmers pruned trees and plants where they suspected the presence of the pest on their property, they should burn all plant parts or place the remnants in garbage bags and bake them in the sun in order to kill the pests (JIS 2007).

6.1.5 Horticultural practices and plant selection: Horticultural practices such as plant spacing, intercropping and species and cultivar selection, including the planting of resistant, poisonous or aromatic plants, such as those discussed above, that seem to be unaffected by, repel or do not produce the type of sap favoured by mealybugs, scales, aphids and other sap-dependent species, are also important cultural control options.

6.2 Chemical Control

Chemical controls include:

6.2.1 Ant baits

Use of ant baits seems to be quite effective. Among the less toxic options, some people have had success using a combination of boric acid or borax, mixed with sugar or honey left in saturated gauze, cotton wool or cloth in saucers in areas of ant traffic, from which small quantities can be carried by armies of foraging workers to ant nests where it is fed to queens and larvae to kill ant colonies. It takes some time, but eventually this action can reduce in size or kill the colony. The important thing about an ant bait is that it should not be so toxic or concentrated so as to kill individual ants quickly before they have had a chance to return to the nest to transfer the toxicant to the colony at large (Bugs for Bugs 2017). More toxic ant baits include the use of the widely available commercial ant baits that contain Fipronil™, a fast-acting ingredient that is also taken back to nests by foraging workers to kill the colony.

6.2.2 Banding, painting or spraying the lower trunk: The banding, painting or spraying the lower trunk or stems of infested plants with insecticide such as Dieldrin™ or Mortein™ has also been used to stop or reduce plant infestation by ants and mealybugs

6.2.3 Low-toxicity chemicals: Application or spraying low-toxicity chemicals such as soapy water, vinegar, lemon juice, cooking oil, turmeric, borax and sugar mixtures (as mentioned above), aromatic oils or commercial misting oils or a combination of these, often mixed with lower toxicity insecticides, such as synthetic pyrethroids to control mealybugs, scales and other insects can also be effective if continued (Jackson 2015, 2016; Huki 2016). The author has, with some success, applied neem oil, an organic but toxic insecticide that reduces insect feeding and acts as a repellent (Beaulieu 2017), by spraying the affected leaves and other plant parts, including the direct removal of existing PHM infestation with a strong jet of the spray. This, along with spraying Mortein™ around the bases of the plants to control ants, seems to have saved a recently transplanted (weakened) **vau leka** (*Hibiscus tiliaceus* var); one of the most important medicinal plants in the Pacific, and has saved or reduced infestations on some of the author's lime trees and Tahitian gardenias, at least on a temporary basis.

6.2.4 High toxicity chemicals: Although a range of highly toxic and dangerous contact and systemic insecticides have been successfully used to control ants, adult mealybugs, scales, etc., they have significant negative human health and environmental impacts, and must be used with utmost care wearing appropriate protective clothing and stored in safe places out of the reach of children and pets, something that is often not done in Fiji. The use and impacts of some of these toxic pesticides are discussed below.

Organophosphate pesticides: Broad-spectrum systemic organophosphate insecticides, such as malathion, acephate (Orthene) and dimethoate (Rogor), are commonly used in Fiji and elsewhere on food crops, fruit trees, in ornamental gardens, on golf courses, in commercial or institutional facilities and as a seed treatment. At one time, acephate, which is sold as powders, liquids, granules, tablets, and in water-soluble packets, was commonly used in and around residences, but most of these uses are no longer allowed in most countries. These are contact and systemic insecticides that rapidly penetrate plant tissues where they are protected from rainfall and irrigation and provide up to three weeks residual control of many damaging pests, including scale insects, aphids and sap-sucking insects. Acephate kills target insects when they touch it or eat it, after which they convert it into another stronger insecticide that affects their nervous systems and kills them (Christiansen 2011; Amvac 2017; Ravensdown 2017).

In recent years the use of Rogor and other organophosphate insecticides has been debated because of their suspected links with cancer and respiratory and cardiac disorders (Morello-Frosch et al. 2011), although some gardeners still used them because of their effectiveness. And most retailers have now stopped selling dimethoate products in Australia, where in 2011, based a dietary risk and assessment report, the Australian Pesticides and Veterinary Medicines Authority determined that it was illegal to use Rogor on any edible crop because dietary exposures exceeded the Australian health standard (the acute reference dose) and prohibited the use of dimethoate on all food producing plants in home gardens, on certain horticultural crops, a finding that is highly relevant to the situation in Fiji (Campbell 2012; APVMA 2017).

Phenylpyrazole and synthetic pyrethroid insecticides: Other broad spectrum insecticides that are used outdoors and surrounding domestic, commercial, public and industrial buildings and structures include the phenylpyrazole insecticide, fipronil (marketed as Termidor in New Zealand), and the systemic synthetic pyrethroid insecticide, bifenthrin, Both are very toxic slow-acting insecticides that disrupt the central nervous systems of insects and are very toxic to bees and beneficial insects, such as the natural predators of mealy bugs, fish and aquatic organisms, and thus having significant knock-on environmental impacts, which as stressed above, may be one of the reasons for the recent outbreak of tea scale in Assam, India (NPTN 1997; NPIC 2011 BASF 2012, Staff reporter 2017).

Neonicotinoids: Reportedly less toxic broad-spectrum systemic insecticides include neonicotinoids, such as Imidacloprid (marketed by Bayer as Confidor) which by the mid-1990s was the most widely used insecticide in the world (Yamamoto 1999) and used in agriculture, arboriculture, gardening, home protection and on domestic animals to control a wide range of insects, including ants, mealybugs, scale insects, aphids, whiteflies, termites, cockroaches, fleas and some beetles (Campbell 2012). Confidor and other neonicotinoids, which can be sprayed on or taken up through plant roots, like other insecticides work by interfering with insect nervous systems. Studies in Europe suggest, however, like more persistent pesticides, imidacloprid and other neonicotinoids are both mobile and persistent, leach into groundwater and into surface water through runoff (Federoff et al. 2008) and cause widespread negative cascading impacts on a wide range of other non-target organisms and ecosystems. Studies have shown, for example, negative impacts on a wide range of non-target invertebrate species, which had led to significant declines in insectivorous birds in the Netherlands (Hallmann *et al.* 2014); and that neonicotinoids pose an unacceptable risk to honey bees and bumble bees and may be a contributing factor to honey bee colony collapse in Europe and North America since 2006 (Carrington 2012; Lu et al. 2012; Whitehorn, et al. 2012).

In summary, all of these toxic insecticides that are currently available and used in Fiji have widespread and increasingly documented long-term negative cascading impacts on a wide range of other non-target organisms, ecosystems services and human health. Their use requires storage in safe, preferably locked places, and the use of protective clothing, gloves, hats, and googles or face protection, preferably a half-face respirator, by people handling or applying the insecticides, all which should be washed afterwards and kept separately from other clothing and equipment. They should never be applied to indoor surfaces; pets and humans should not be allowed in the area during application; they should normally not be applied to edible plants; and should not be used if heavy rains are expected to occur within 48 hours of application or when soil is wet.

6.3 Biological Control

Sadly, most reports indicate that if these cultural and chemical controls are not continued, the ants and mealy bugs will return a month or two later, with studies in Dominica showing that, even if continued, insecticides only worked to 20—30% effectiveness in the control of SS infestations (DNO 2015). And, given the high cost and human health and environmental hazards associated with indiscriminate insecticide use and the difficulty of removing and destroying infested materials, the only long-term answer to the WFA-MB bioinvasion seems to be biological control using the natural predators, parasites and diseases of the mealybugs, a technique that has long been used successfully in Asia, Europe, the United States and elsewhere for the controls of scale insects and mealybugs, but only recently employed in the Pacific (Rechcigl and Rechcigl 1998). Among the natural enemies of mealybugs are a range of parasitic wasps (*Leptomastix* spp.), predatory ladybird beetles *(Cryptolaemus montrouzieri and Radolia* spp.*),* green lacewings *(Mallada signata)* and a number of other predatory or parasitic insects *(Bugs for Bugs 2015b,* HUJI *2016).*

This is supported by studies of HMB and other polyphagous scale insects, including the Columbian fluted scale *(Crypticerya multicicatrices)*, that were unintentionally introduced with plants from the mainland to Columbia's offshore Caribbean islands, but only controlled when the a native predator of the scale insect was unintentionally introduced from mainland Columbia (Kondao et al. 2014). In Jamaica, where the mealy bugs had caused an estimated $3 million crop loss per year in the early 2000s, the only way to control the mealybug in the long-term was believed to be the introduction of obligate predators and parasites, such as parasitic wasps, natural enemies of the pest, which when released lay their eggs on the immature stages of the mealy bugs and after hatching the larvae feed internally on the mealybugs. Where these wasps had been released in the Caribbean and the United States, there was a 90 to 95 per cent drop in the mealybug populations (JIS 2007); studies 5 months after releasing *Anagyrus kamali*, a parasitic wasp from China, there was reportedly an 80—90 % reduction in population density of the PHM at release sites (Mani and Gul 2016); and effective control of SS was reportedly achieved in Mauritius by introducing the parasitic fly (*Chryptochetum monophlebi)* (HUJI 2016).

Closer to home, predatory ladybird beetles from Australia, such as *Rodolia limbata* were successfully introduced to control breadfruit mealybug *(Icerya aegyptiaca)* in FSM, Kiribati, the Marshall Islands and Palau in Micronesia where it was reducing fruit yields by up to 50% (Mani and Gul 2016); *Rodolia cardinalis* was reportedly introduced into the Cook Islands in the late 1930s to control SS, which had become established on Aitutaki and Rarotonga; and *R. pumila* was released on Rarotonga in 1974 (Walker and Deitz 1979). Although the SS is recorded present in the *Cook Islands Biodiversity Database*, there is no photo and no associated data, indicating that it may no longer be a problem there and possibly controlled by these previously introduced predators (McCormick 2007). Finally, the SPC has reportedly successfully controlled mealybugs around its Suva headquarters in Fiji using an imported Australian ladybird, the mealybug destroyer (*Cryptolaemus montrouzieri)* (MBD), which is recognised worldwide as a voracious predator of mealybugs, capable of eating 3,000-5,000 mealybugs in various life stages during its lifetime (Mani and Gul 2016; Martin 2016). This is supported by the discovery, during the current study, of remnant populations of MBD larvae and adults on mealybug and scale infested gardenia and ixora plants. One complicating factor is that because of their heavy wax coating, the larvae of MBD, have apparently evolved to look very similar to and are often mistaken for large mealybugs, and unsuspectingly inadvertently killed by the use of insecticides, which are very toxic to ladybirds and other insects. It is consequently recommended that insecticides use be avoided where possible, and, if used, that four weeks should elapse before biocontrol insects such as *Cryptolaemus* ladybirds are released (Bugs for Bugs 2015b).

However, as stressed above, the most serious obstacle to the successful introduction and effectiveness of biocontrol agents is that the toxic insecticides discussed above kill and threaten the long-term effectiveness of biological control.

7 FURTHER STUDIES

This is only a first exploratory study focused on trying to understand the extent and nature of the 2016 Fiji Ant-Mealybug Bio-invasion and opportunities for, and obstacles to its control and management, and there is obviously need for further, more-in-depth studies. Some suggested areas for further study include:

1. More-in-depth studies of the geographical extent, habitat preferences and the range of invasive and host species involved in the bio-invasion,

2. Similar studies on other Pacific Islands.

3. Studies of natural, mainly forest, ecosystems on both main inhabited and uninhabited offshore islets, such as the studies carried out on Aldabra Atoll in the Seychelles in the 1970s—80s to asses impacts on less-humanised ecosystems.

4. Studies in Fijian village gardens, rural household gardens and other urban gardens, landscaping and botanical gardens and nurseries.

5. Studies in rural agricultural areas, such as the Fiji sugarcane belt, ginger and banana growing areas, the Sigatoka Valley, Taveuni taro farming areas and areas of Fijian shifting cultivation.

6. Studies of the presence or absence of predators and parasites, both native and introduced, and the impact of ants and the use of insecticides on them.

7. Studies of the long-term effectiveness of different integrated pest management regimes, including the use of non-toxic and toxic substances and insecticides and the potential impacts on other organisms, ecosystem services and human health, including impacts on natural predators of plant invaders.

8. Studies of the history of the use and effectiveness of biological control of ants, mealybugs scale insects and other sap-sucking insects, both locally and internationally and the identification of promising biocontrol agents and strategies for biocontrol implementation in Fiji and elsewhere in the Pacific Islands.

9. Economic evaluation of the economic, social and environmental costs of the 2016 Fiji Ant-Mealybug Bio-invasion.

REFERENCES

ALA. 2016 (original1999). *Icerya seychellarum* (Westwood, 1855). *Atlas of living Australia*. http://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:4e46389a-1999-443a-b91d-af9be9950fd0 (Accessed 17 July 2017)

Allwood, A.J., Chinajariyawong, A., Drew, R.A.I., Hamacek, E.L., Hancock, D.L., Hengsawad, C., Jinapin, J.C., Jirasurat, M., Kong Krong, C., Kritsaneepaiboon, S., Leong, C.T.S., and Vijaysegaran, S. 1999. Host plant records for fruit flies (Diptera: Tephritidae) in South-East Asia. *The Raffles Bulletin of Zoology*. Supplement 7: 1 – 92. (Complete host list in Asia).

Aloalii, I., Masamdu, R., Theunis, W. and Thistleton, B.M. 1993. Prospects for biological control of *taro beetles, Papuana* spp. (Coleoptera: Scarabaeidae) in the South Pacific. In *Ferentinos, L*. (ed.) *Proceedings of the sustainable taro culture for* the *Pacific Conference. East-West Center, University of Hawaii, September 24 and 25, 1992*. Research Extension Series. College of Tropical Agriculture and Human Resources. University of Hawai'i, Honolulu. Pp. 66 – 70.

Anderson, W. 2000. Infectious diseases: Colonising the Pacific? (Review*). Bulletin of the History of Medicine* 74 (3): 617-618 | 10.1353/bhm.2000.0103

Amvac. 2017. Orthene® 97 Soluble Insecticide. Amvac Chemical Corporation, http://www.amvac-chemical.com/Product-Details/pid/180 (Accessed 21 June, 2017) APHIS (Animal and Plant Health Information Service). 1996. The hibiscus or pink mealy bug https://www.aphis.usda.gov/aphis/banner/help.

APVMA (Australian Pesticides and Veterinary Medicine Authority). 2017. Dimethoate Chemical Review. https://apvma.gov.au/dimethoate (accessed 23 June 2017).

Argueta A. 1994. *Atlas de la medicina tradicional Mexicana*. Vo. 1. Instituto Nacional Indigenista, Mexico México, D.F.

Auina, S.S.A., Stanley. M. and Hoffman, B. 2011. Impacts of *Anoplolepis gracilipes* (yellow crazy ant) on invertebrate communities in Nu'utele, Samoa. *AGRIS. http://agris.fao.org/agris-search/search.do?recordID=AV2012084108 (*Accessed 8 August 2017).

BAF. 2014. Asian Subterranean Termites. Biosecurity Authority of Fiji. http://www.baf.com.fj/news/asian-subterranean-termites (Accessed 8 August 2017)

BASF. 2012. Termidor 100 SC. Termidor Ant Control. http://agro.basf.co.nz/products/insecticides/termidor-100-sc.aspx (Accessed 22 June 2017).

Beaulieu, D. 2017. Using neem oil as an organic insecticide - Review: It's Green and It's Mean. *The Spruce* 24 April. https://www.thespruce.com/using-neem-oil-as-an-organic-insecticide-2132579 (Accessed 21 June 2017)

Berry, F. and Kress, W.J. (eds.). 1991. *Heliconia: An identification guide*. Smithsonian Institution Press, Washington D.C and London.

Bolton, B. 2007. Taxonomy of the dolichoderine ant genus *Technomyrmex* Mayr (Hymenoptera: Formicidae) based on the worker caste. *Contributions of the American Entomological Institute* 35: 1-149.

Brodie G, Barker GM, Stevens F, Fiu M. 2014. Preliminary re-survey of the land snail fauna of Rotuma: conservation and biosecurity implications. *Pacific Conservation Biology* 20 (1): 94—107.

Brodie G, Stevens F, Barker G. 2012. Report on a preliminary survey of the land snail fauna of Rotuma. Available at *http://www.rotuma.net/os/Publications/land_snail_survey.pdf*.

Brown, S. H. 2013. *Clerodendrum quadriloculare*. Family: Lamiaceae. Fact sheet. UF/IFAS Lee County Extension, University of Florida, Fort Myers. file:///C:/Users/HP/Downloads/Starburst_Clerodendrum.pdf (Accessed 6 Sept. 2017)

Bugs for Bugs. 2015a. Ant Control. Bugs for Bugs: Pest management specialists for over 35years. https://bugsforbugs.com.au/2017/01/ant-control/ (Accessed 23 June 2017)

Bugs for Bugs. 2015b. *Cryptolaemus*. Bugs for Bugs: Pest management specialists for over 35years. https://bugsforbugs.com.au/product/cryptolaemus/ (Accessed 23 June 2017)

Bugwood. 2003. Watch Out for the Pink Hibiscus Mealybug. *The Bugwood Network*. Dept. of Entomology,Warnell School of Forestry and Natural Resources and College of Agricultural and Environmental Sciences. https://www.bugwood.org/factsheets/mealybug.html (Accessed 22 July 2017)

Burne, A. and Gruber, M. 2016. Yellow crazy ants have invaded Tokelau (YouTube video). Pacific Invasive Ant Toolkit July 10. https://www.youtube.com/watch?v=VBhUSLdvFfw (Accessed 8 August 2017).

Butler, A. and Bax, N. 2014. Seas and coasts. In Morton, S., Sheppard, A and Lonsdale, M. (eds.). 2014. *Biodiversity: science and solutions for Australia*. CSIRO Publishing, Collingwood, Melbourne.

CABI/EPPO. 2004. *Maconellicoccus hirsutus*. *Distribution maps of plant pests* no. 100. CAB International, Wallingford, Great Britain.

CABI/EPPO, 2008. Icerya seychellarum. [Distribution map]. Distribution Maps of Plant Pests, June (1st revision). Wallingford, UK: CABI, Map 52.

CABI. 2012. Bambusaspis bambusae. CABI Invasive Species Compendium. http://www.cabi.org/isc/datasheet/112656 (Accessed 7 Sept. 2017)

CABI. 2016a. Nipaecoccus nipae (spiked mealybug). CABI Invasive Species Compendium. http://www.cabi.org/isc/datasheet/36334 (Accessed 2 Sept. 2017)

CABI. 2016b. Icerya seychellarum (Seychelles scale). CABI Invasive Species Compendium. http://www.cabi.org/isc/datasheet/28434 (Accessed 17 July 2017)

CABI. 2017a. Coccus hesperidum (soft brown scale). CABI Invasive Species Compendium. https://www.cabi.org/isc/datasheet/14664 (Accessed 23 Dec. 2017)

CABI. 2017b. Diaspidiotus perniciosus (San José scale). CABI Invasive Species Compendium. https://www.cabi.org/isc/datasheet/46224 (Accessed 23 Dec. 2017).

CABI. 2017c. Dysmicoccus brevipes (pineapple mealybug). CABI Invasive Species Compendium. http://www.cabi.org/isc/datasheet/20248 (Accessed 11 Sept. 2017)

Campbell, C. 2012. Gardening: Pest treatment horror file. *Courier Mail* (Online) March 9. http://www.couriermail.com.au/lifestyle/health/garden-pest-treatment-horror-file/news-story/865487d47be65ac68206cf14b10cc998?sv=9b8052eb971a7b01fd380238e7cdd232 (Accessed 22 June 2017)

Campbell, F. 2005. Cycad aulacaspis scale (sago palm scale, Asian cycad scale) - *Aulacaspis yasumatsui* Takagi. *Gallery of Pests: Pests & pathogens that are widespread; vectors should be managed.* Global Invasive Species Team, The Nature Conservancy. https://www.invasive.org/gist/products/gallery/aulya1.html (Accessed 24 Aug. 2017),

Campbell, F. 2010. Erythrina gall wasp: *Quadrastictus erythrinae*. *Don't Move Firewood*. http://www.dontmovefirewood.org/gallery-of-pests/erythrina-gall-wasp.html (Accessed 10 Jan. 2014).

Carrington, D. 2012. Pesticides linked to honeybee decline. *The Guardian* March 29. Retrieved April 7, 2012. https://www.theguardian.com/environment/2012/mar/29/crop-pesticides-honeybee-decline (Accessed 22 June 2017)

Carver M. 1978. The black citrus aphids, *Toxoptera citricidus* (Kirkaldy) and *T. aurantii* (Boyer de Fonscolombe) (Homoptera: Aphididae). *Journal of the Australian Entomological Society* 17: 263-270.

Center for Invasive Species and Ecosystem Health. 2017. Pink hibiscus mealybug *Maconellicoccus hirsutus* (Green) (78 images). Invasive.org: https://www.invasive.org/browse/subthumb.cfm?sub=9222 (Accessed 22 June 17)

CGAPS. 1996, *Stop the Silent Invasion*. Coordinating Group on Alien Pest Species, Honolulu, 1996).

Chong, J-H., Aristizabal, L.F. and Arthurs, S.P. 2015. Biology and Management of *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae) on Ornamental Plants. *Journal of Integrated Pest Management* 6(1); 5. DOI: 10.1093/jipm/pmv004. https://www.researchgate.net/publication/275950647_Biology_and_Management_ of_Maconellicoccus_hirsutus_Hemiptera_Pseudococcidae_on_Ornamental_Plants (Accessed 22 July 2017).

Christiansen, A., Gervais, J., Buhl, K. and Stone, D. 2011. Acephate General Fact Sheet. National Pesticide Information Center, Oregon State University Extension Services. http://npic.orst.edu/factsheets/acephagen.html. (Accessed 23 June 2017).

CIE, 1955. Distribution Maps of Plant Pests. No. 52. UK: CAB International, Wallingford.

Clausen CP, 1978. Introduced Parasites and Predators of Arthropod Pests and Weeds: a World Review. Agricultural Handbook No. 480. Washington DC, USA: Agricultural Research Service, United States Department of Agriculture.

Coles, S.L., DeFelice, R.C., Eldredge, L.G. and Carlton, J.T. 1999. *Historical and recent introductions of non-indigenous marine species into Pearl Harbor, Oahu, Hawaiian Islands.* Department of Natural Sciences, Bishop Museum, Honolulu.

Cuddihy, L.W. and Stone, C.P. 1990. Alteration of the native Hawaiian vegetation: Effects of humans, their activities and introductions. Cooperative National Park Resources Studies Unit, University of Hawaii, Manoa. http://manoa.hawaii.edu/hpicesu/book/book_all_1990.pdf (Accessed 11 Aug. 2017).

DeFilipps, R.A., Maina, S.L. and Crepin, J. 2004. *Medicinal Plants of the Guianas (Guyana, Surinam, French Guiana)*. Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Deyrup M. 1991. *Technomyrmex albipes*, a new exotic ant in Florida (Hymenoptera: Formicidae). *Florida Entomologist* 74: 147-148.

Dıaz, S., Sebsebe, D., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J.R., Arico, S., Baldi, A., Bartuska, A., Baste, I.A., Bilgin, Brondizio, E., Chan, K.M., Figeroa, V.E., Duraiappah, A., Fischer, M., Hill, R., Koetz, T., Leadley, P., Lyver, P., Mace, G.M., Martin-Lopez, G., Okumura, M., Pacheco, D., Pascual, U., Perez, E.S., Reyers. B., Roth, E., Saito, O., Scholes, R.J., Sharma, N., Tallis, H., Thaman, R., Watson, R., Yahara, T., Hamid, Z.A., Akosim, C., Yousef, A.-H., Allahverdiyev, R., Amankwah, E., Asah, T.S.,

Asfaw, Z., Bartus, G., Brooks, A.L., Caillaux, J., Dalle, G., Darnaed, D., Driver, A., Erpul, G., Escobar-Eyzaguirre, P., Failler, P., Fouda, A.M.M., Fu, B., Gundimeda, H., Hashimoto, S., Homer, F., Lavore, S., Lichtenstein, G., Mala, W.A., Mandivenyi, W., Matczak, P., Mbizvo, C., Mehrdadi, M., Metzger, J.P., Mikissa, J-B., Moller, H., Mooney, H.A., Mumby. P., Nagendra, H., Nesshover, C., Oteng-Yeboah, A.A., Pataki, G., Roue, M., Rubis, J., Schultz, M., Smith, P., Sumaila, R., Takeuchi, K., Thomas, S., Verma, M., Yeo-Chang, Y. and Zlatanova, D. 2015. The IPBES Conceptual Framework — connecting nature and people. *Current Opinion in Environmental Sustainability* 14:1—16. www. science direct.com.

Dinesh, D.S, Kumari, S., Kumar, V. and Das, P. 2014. The potentiality of botanicals and their products as an alternative to chemical insecticides to sandflies (Diptera: Psychodidae): a review. *Journal of Vector Borne Diseases* 51 (1):1-7.

DNO (Dominica News Online. 2015). Warning against insecticide in battling Scale Insect invasion. Dominica News Online June 19. http://dominicanewsonline.com/news/homepage/news/general/warning-against-insecticide-in-battling-scale-insect-invasion/ (Accessed 17 June 2017)

Dumbleton, L.J, 1954. *A list of insects recorded in South Pacific territories.* South Pacific Commission Technical Paper No. 79: 202 pp.

Dumbleton, L.J, 1957. *Parasites and predators introduced in the Pacific Islands for the biological control of insects and other pests.* South Pacific Commission Technical Paper, No. 101, 40 pp.

Economo. E.P. and Sarnat, E.M. 2012. Revisiting the Ants of Melanesia and the Taxon Cycle: Historical and Human-Mediated Invasions of a Tropical Archipelago. *American Naturalist* 180 (1): E1—E16. DOI: 10.1086/665996.

Elton, C.S. 1958. *The ecology of invasion of by animals and plants.* Methuen, London.

El Wanis. M.A. c.2010. Mealybugs: Types of mealybugs deployed on different plant hosts in Egypt. Powerpoint. https://kenanaonline.com/files/0005/5738/mealybugs.ppt (Accessed 23 August 2017).

EPPO, 2014. PQR database. Paris, France: European and Mediterranean Plant Protection Organization. http://www.eppo.int/DATABASES/pqr/pqr.htm

Fasi, J., Brodie, G. and Vanderwoude, C. 2013. Increases in crop pests caused by *Wasmannia auropunctata* in Solomon Islands subsistence gardens. *Journal of Applied Entomology* 137 (8); 580 – 588.

Federoff, N.E., Vaughan, A. and Barrett, M.R. 2008. *Problem formulation for the Imidacloprid environmental fate and ecological risk assessment*. Office of Prevention, Pesticides, and Toxic Substances, U. S. Environmental Protection Agency. Washington D.C.

Fondeur, J. 1991. Appendix I. Cultivation of heliconias. In Berry, F. and Kress, W.J. (eds.), *Heliconia: An identification guide*. Smithsonian Institution Press, Washington and London. pp. 309—313.

Forel, A. 1892. Hyménoptères 2 (supplement au 28 fascicule). Les Formicides. In: Grandidier, A. (Ed.), *Histoire physique, naturelle & politique de Madagascar* 20. Hachette & Cie, Paris, pp. 232-280.

Foral, A. 1911, Aperçu sur la distribution géographique & la phylogénie des fourmis. – *Memoires 1er Congrès International d'Entomologie* 2: 81-100.

Franco, J.C., Suma, P., da Silva, E.B., Blumberg, D. and Mendel, Z. 2004. Management Strategies of Mealybug Pests of Citrus in Mediterranean Countries. *Phytoparasitica* 32(5): 507-522.

Friday, J.B. and Okano, D. 2006. Cordia subcordata (kou). Species Profiles for Pacific Island Agroforestry. http://www.primitiveways.com/Cordia-kou.pdf (Accessed 11 Aug. 2017).

Galbreath, R. 2008. Agricultural and horticultural research. *Te Ara: The Encyclopedia of New Zealand***.** http://www.TeAra.govt.nz/en/document/19681/biological-control (accessed 20 July 2017).

Gilman, E.F. and Watson, D.G. 2013 *Delonix regia: Royal poinciana*. Southern Tree Fact Sheets. IAF Extension, University of Florida. Publication #ENH387. http://edis.ifas.ufl.edu/pdffiles/ST/ST22800.pdf (Accessed 7 Sept. 2017)

Global Invasive Species Database. 2009. Species profile: *Technomyrmex albipes*.. http://www.iucngisd.org/gisd/species.php?sc=1061 (Accessed 1 Sept. 2017).

Goombridge, B. 1992. *Global biodiversity: status of the earth's living resources*. Chapman and Hall, London.

Gruber, M. 2016. White-footed ants. *Pacific Invasive Ant Toolkit*. AntWeb, (www.antweb.prg) http://www.piat.org.nz/problem-ants/common-invasive-ants/white-footed-ants (Accessed 31 May 2017)**.**

Gruber M.A.M., Hoffmann B.D., Ritchie P.A. and Lester, P.J. 2012. Recent behavioural and population genetic divergence of an invasive ant in a novel environment. *Diversity and Distributions* 18:323–333.

Guevera, A.P., Apilado, A., Sakarai, H., Kozuka, M. and Tokunda, H. 1996. Anti-inflammatory, antimutagenecity and antitumor promoting activities of mahagony seeds, *Swietenia macrophylla* (Meliaceae). *Philippines Journal of Science* 125: 271-278.

Halbert, S.E. and Brown, L.G. 2014. Brown citrus aphid scientific name: *Toxoptera citricida* (Kirkaldy) (Insecta: Hemiptera: Aphididae). *Featured creatures*. UF/IFAS, University of Florida. http://entnemdept.ufl.edu/creatures/citrus/bc_aphid.htm (Accessed 30 Aug. 2017).

Hallmann, C.A., Foppen, R.P., van Turnhout, C.A., de Kroon, H. and Jongejans. E. 2014. Declines in insectivorous birds are associated with high neonicotinoid concentrations. *Nature* 511(7509):341-3. doi: 10.1038/nature13531. Epub 2014 Jul 9.

Hammond, A. C. 1995. *Leucaena* toxicosis and its control in ruminants. *Journal of Animal Science* 73: 1487-1492.

Hill, M.G. and Blackmore, P.J. 1980. Interactions between ants and the coccid *Icerya seychellarum* on Aldabra atoll. *Oecologia* 45 (3):360-365. doi: 10.1007/BF00540206.

Hill, M.G. and Newbery, D.M. 1980. The distribution and abundance of the coccid *Icerya seychellarum* Westw. On Aldabra Atoll. *Ecological Entomology* 5: 155—122.

Hay, R., McQuown, F.R. and Beckett, K. 1974. *The dictionary of indoor plants in colour*. Peerage Books in collaboration with the Royal Horticultural Society, London.

Hodgson, C. J. and Łagowska, B. 2011. New scale insect (Hemiptera: Sternorrhyncha: Coccoidea) records from Fiji: three new species, records of several new invasive species and an updated checklist of Coccoidea. *Zootaxa* 2766: 1—29.

Howarth, F. 1985. Impacts of alien land arthropods and molluscs on native plants and animals in Hawaii. In C. P. Stone and J. M. Scott (eds.). *Hawaii's Terrestrial Ecosystems: Preservation and Management,* University of Hawaii Press, Honolulu.

HUJI (Hebrew University of Jerusalem). 2016. *Icerya seychellarum* (Westwood). *Plant pests of the Middle East*. http://www.agri.huji.ac.il/mepests/pest/Icerya_seychellarum/ (Accessed 22 August 2017)

Hunter, D., Pouono, K. and Semisi, S. 1998. The impact of taro leaf blight in the Pacific Islands with special reference to Samoa. *Journal of South Pacific Agriculture* 5: 44-56.

Idtools. 2014a. Scale insects: Icerya seychellarum (Westwood). *Identification Tool for Species of Quarantine Significance***.** Edition 2. http://idtools.org/id/scales/factsheet.php?name=6955 (Accessed 22 August 2017)/

Idtools. 2014b, Scale insects: *Parasaissetia nigra* (Nietner), *Identification Tool for Species of Quarantine Significance*. Edition 2. http://www.idtools.org/id/scales/factsheet.php?name=6895 (Accessed 28 Aug. 2017)

Idtools. 2014c, Scale insects *Protopulvinaria pyriformis Cockerell. Identification Tool for Species of Quarantine Significance*. Edition 2. http://idtools.org/id/scales/factsheet.php?name=6902 (Accessed 3 Sept. 2017)

ISSG (IUCN Invasive Species Specialist Group). 2009. *Technomyrmex albipes* (insect.). http://issg.org/database/species/ecology.asp?si=1061&fr=1&sts=&%20ang=TC&ver=print&prtflag=false (Accessed 18 June 2017).

Jackson, G. 2015. Breadfruit mealybug (184). Pacific Pests and Pathogens Fact Sheet. *Pestnet*. http://www.pestnet.org/fact_sheets/breadfruit_mealybug_184.htm (Accessed 19 Aug. 2017).

Jackson, G. 2016a. Breadfruit (Seychelles) scale (242). Pacific Pests and Pathogens Fact Sheet. *Pestnet*. http://www.pestnet.org/fact_sheets/breadfruit_seychelles_scale_242.htm.

Jackson, G. 2016b. Frangipani rust (243). Pacific Pests and Pathogens Fact Sheet 243. *Pestnet*. http://www.pestnet.org/fact_sheets/frangipani_rust_243.htm

JIS (Jamaica Information Service). 2007. Controlling Ants Key to Containment of Pink Mealy Bug. 9 July. http://jis.gov.jm/controlling-ants-key-to-containment-of-pink-mealy-bug/ (accessed 9.5.17)

Jourdan, H. 1997 Threats on Pacific islands: the spread of the Tramp Ant *Wasmannia auropunctata* (Hymenoptera: Formicidae). *Pacific Conservation Biology* 3 (1) 61 – 64.

Kauffman, A. 2016. How to get rid of ants with three ingredients. *The Happy Housewife*. July. http://thehappyhousewife.com/home-management/how-to-get-rid-of-ants-with-three-ingredients/ (Accessed 2 Sept. 2017)

Kohler, F., Pellegrin, F., Jackson. G. and McKenzie, E. 1997. *Diseases of cultivated crops in Pacific Island countries*. South Pacific Commission, Noumea. http://cnas-re.uog.edu/wp-content/uploads/2017/04/Diseases-of-the-Pacific-Islands.pdf (Accessed 2 Sept. 2017)

Kondo, T., Gullan, P. and Gonzales, G. 2014. An overview of a fortuitous and efficient biological control of the Colombian fluted scale, *Crypticerya multicicatrices* Kondo & Unruh (Hemiptera: Monophlebidae: Iceryini), on San Andres island, Colombia. *Acta Zoologica Bulgarica* Suppl. 6: 87-93.

Kremoin. J. 1990. *Palms & cycads round the world*. Horowitzh Grahame, Sydney.

Lasch, L. and Hoskin, C. 2015. Too much to lose: Yellow crazy ants in the wet tropics. *Wildlife Australia* Spring: 52 (3): 37—41. http://www.wettropics.gov.au/site/user-assets/docs/yellow-crazy-ants-lach--hoskin-spring-2015.pdf (Accessed 8 august 2017)

Leathers, J. 2016. *Ceroplastes rubens* Maskell: red wax scale. Hemiptera, insects, mites & earthworms. http://blogs.cdfa.ca.gov/Section3162/?p=3008 (Accessed 30 Aug. 2017)

Le Breton, J., Chazeau, J., and Jourdan, H. 2003. Immediate impacts of invasion by *Wasmannia auropunctata* (Hymenoptera: Formicidae) on native litter ant fauna in a New Caledonian rainforest. *Austral Ecology* 28:204-209.

Lever, R.J.A.W. 1946. Insect pests in Fiji. *Bulletin, Department of Agriculture, Fiji* 16: 41-44.

Lever, R.J.A.W. 1947. Insect pests of some economic crops in Fiji. No. 2. *Bulletin of Entomological Research* 38(1): 137—143.

Lu, C., Warchol, K. M and, Callahan, R. A. 2012. In situ replication of honey bee colony collapse disorder. *Bulletin of Insectology* 65 (1): 99--106. ISSN 1721-8861. http://www.bulletinofinsectology.org/pdfarticles/vol65-2012-099-106lu.pdf (Accessed 23 June 2017)

MA. 2005. *Ecosystems and human well-being: current state and trends, Vol 1. Millennium Ecosystem Assessment.* Island Press, Washington, London.

MacArthur, N. 1968. *Islands population of the Pacific*. Australian National University Press, Canberra.

MacDonald, I.A.W. and Cooper, J. 1995. Insular Lessons for Global Biodiversity Conservation with Particular Reference to Alien Invasions. In Vitousek, P.M., Loope, L.L. and Anderson, H. (eds.), *Islands biological diversity and ecosystem function*. *Ecological Studies* 15: 189—203.McCrae, M. 2017. Guam's Plague of Snakes Is Devastating The Whole Island Ecosystem, Even The Trees. *Science Alert*. 11 March https://www.sciencealert.com/guam-s-plague-of-snakes-is-having-a-devastating-impact-on-the-trees (Accessed 6 August 2017).

McCormack, G. 2007. *Cook Islands Biodiversity Database*. Version 2007.2. Cook Islands Natural Heritage Trust, Rarotonga. Online at http://cookislands.bishopmuseum.org.

McKenzie, H. L., 1967. *Mealybugs of California*. University of California Press, Berkeley, pp. 32-33.

Mangoud, A. A. H., Salem, M. A. and Abd El-Aziz, M. A. 2012. Effect of different compounds on *Icerya seychellarum* (Hemiptera: Monophlebidae) and *Rodalia cardinalis* (Coleoptera: Coccinellidae) on mango leaves under laboratory conditions. *Egyptian Academy Journal of Biological Science* 5(3): 113 -119.

Mani. M. and Gul. S. 2016. Mealybug alikes. Chapter 18 in M. Mani and C. Shivaraju (eds.), *Mealybugs and their Management in Agricultural and Horticultural crops*. Springer, India DOI 10.1007/978-81-322-2677-2_18.

Martin, K.W., Hodges, A. C. and Leppla, N.C. 2012. Citrus mealybug. *Citrus pests: factsheet*. *Idtools*. http://idtools.org/id/citrus/pests/factsheet.php?name=Citrus%20mealybug (Accessed 10 Sept. 2017)

Martin N A. 2016. Mealybug ladybird - *Cryptolaemus montrouzieri*. Interesting Insects and other Invertebrates. New Zealand Arthropod Factsheet Series Number 50. Landcare Research. ISSN 1179-643X. http://nzacfactsheets.landcareresearch.co.nz/Index.html. (Accessed 3 Sept. 2017).

Martin, P.M.V. and Combes, C. 1996. Emerging infectious diseases and the depopulation of French Polynesia in the 19th Century. *Emerging Infectious Diseases* 2 (4): 359-361.

Maskell, W.M. 1893. *Icerya purchasi*. *Wanganui Herald* 22 June: 2.

Mau, R.F.L. and Kessing, J.L.M. 2007. *Parasaissetia nigra* (Nietner): Nigra scale. Crop Knowledge Master. http://www.extento.hawaii.edu/kbase/crop/type/p_nigra.htm (Accessed 28 Aug. 2017)

Mesbah, H.A., Magda A.-K., Mourad, A.K., Abdel-Razak, S.I., Weheda, M.L., Zaghloul O.A. and Samar, E.A. 2009. Efficacy of five volatile oils and their mixtures against the mealybug, *Icerya seychellarum* (Westw.) infesting Sago palm, *Cycas revoluta* in Alexandria, Egypt. *Communications in Agriculture and Applied Biological Science* 74 (2): 445-55.

Mesbah, H. A., Moursi, K. S., Mourad, A.K., Zakzouk, E. A. and Abdel-Fattah, R. S 2012. Ecological studies on the common white mealybug, *Icerya seychellarum* (Hemiptera : Monophlebidae) associated with *Dodonaea viscosa* in Alexandria, Egypt. *Egyptian Academy Journal of Biological Science* 5(3): 27-31.

Meyerdirk, D.E., R. Warkentin, R., Attavian, R.B., Gersabeck, E., Francis, A., Adams, M. and Francis, G. 2001. *Biological Control of Pink Hibiscus Mealybug Project Manual*. 02/2001-01. United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) & International Services (IS), Riverdale, MD.

Miles, J. 1997. *Infectious Diseases: Colonising the Pacific.* University of Otago Press, Dunedin.

Moghadamtousi, S.Z., Goh, B.H., Chan, C.K., Shahab, T. and Kadir, H.A. 2013. Biological activities and phytochemicals of *Swietenia macrophylla* King. *Molecules* 18: 10465-10483. doi:10.3390/molecules180910465

Moore, A., Iriarta, I. and Quitugua. R. 2005. Asian cycad scale *Aulacaspis yasumatsui* Takagi (Homoptera: Diaspididae). Pest Sheet 2005-01. Cooperative Extension Service, Agriculture and Natural Resource Division, University of Guam, Agaña.

Morales. C.F. 1993. Maskell, William Miles, first published in the *Dictionary of New Zealand Biography*, vol. 2 and later in *Te Ara: the Encyclopedia of New Zealand.* http://www.TeAra.govt.nz/en/biographies/2m37/maskell-william-miles (Accessed 20 July 2017),

Morello-Frosch, R., Zuk, M., Jerrett, M., Shamasunder, B. and Kyle, A.D. 2011. Understanding the cumulative impacts of inequalities in environmental health: implications for policy. *Health Affairs* 30 (5): 881. doi:10.1377/hlthaff.2011.0153

National Research Council. 1992. *Neem: A Tree for Solving Global Problems*. Report of an Ad Hoc Panel of the Board on Science and Technology for International Development National Research Council. National Academy Press, Washington, D.C.

Nelson, S. 2009. Plumeria rust. Plant Disease 61. College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu. https://www.ctahr.hawaii.edu/oc/freepubs/pdf/pd-61.pdf (accessed 27 Aug. 2017)

Newbery, D.M. 1980. Interactions between the coccid, *Icerya seychellarum* (Westw.) and its host tree species on Aldabra Atoll: II. Scaevola taccada (Gaertn.) Roxb. *Oecologia* 46(2): 180-185. doi: 10.1007/BF00540124.

Newbery, D.M. and Hill, M.G. 1985. Changes in the distribution of the Coccid *Icerya seychellarum* Westw. on Aldabra Atoll in relation to vegetation density, *Atoll Research Bulletin* 291: 1—12.

NISIC (National Invasive Species Information Center). 2012. Pink hibiscus mealybug *(Maconellicoccus hirsutus)*. USDA-NAL National Invasive Species Information Center Species Profiles. http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=40171 (Accessed 28 Aug. 2017).

NISIC (National Invasive Species Information Center). c. 2014. long-tailed mealybug (*Pseudococcus longispinus*). USDA-NAL National Invasive Species Information Center Species Profiles. http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=45079 (Accessed 3 Sept. 2016)

NISIC (National Invasive Species Information Center). c. 2015. Brown soft scale (*Coccus hesperidum*). https://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=14664 (Accessed 23 Dec. 2017).

NISIC (National Invasive Species Information Center). c. 2015. Circular scale (*Chrysomphalus aonidum*). USDA-NAL National Invasive Species Information Center Species Profiles. http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=13379 (Accessed 29 Aug. 2016).

NPIC. 2011. Bifenthrin Technical Fact Sheet. National Pesticide Information Center, Corvallis. http://www.ssvotech.org/wp-content/uploads/2016/04/Bifenthrin-fact-sheet.pdf (Accessed 11 Sept. 2017)

NPIC. 2012. Acephate: General fact sheet. National Pesticide Information Center. http://npic.orst.edu/factsheets/acephagen.html (Accessed 23 June 2017).

NPTN. 1997. Fipronil. NPTN Fact Sheet. National Pesticide Telecommunications Network. http://www.livingwithbugs.com/PDFiles/fipronil.pdf (Accessed 22 June 2017).

NSW DPI (New South Wales Department of Primary Industries). 2015. Exotic Pest Alert: Pyriform Scale. *Primefact* 1416. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/567472/exotic-pest-alert-pyriform-scale.pdf (Accessed 3 Sept. 2017)

N'Yeurt, A. de R. and Iese, V. 2015. The proliferating brown alga *Sargassum polycystum* in Tuvalu, South Pacific: assessment of the bloom and applications to local agriculture and sustainable energy. *Journal of Applied Phycology* 27(5): 2037—2045. ISSN 0921-8971.

O'Dowd, D.J., Grant, P.T. and Lake, P.S. 2003. Invasional meltdown on an oceanic island. *Ecology Letters* 6: 812–817. doi: 10.1046/j.1461-0248.2003.00512.x

OEPP/EPPO (European and Mediterranean Plant Protection Organization). 2005. Data sheets on quarantine pests: *Maconellicoccus hirsutus*. *OEPP/EPPO Bulletin* 35: 413–415. https://www.eppo.int/QUARANTINE/data_sheets/insects/DS_Maconellicoccus_hirsutus.pdf (Accessed 20 June 2017)

Pacific Biosecurity. 2016. White-footed ants. *Pacific Invasive Ant Toolkit (PIAT)*. http://www.piat.org.nz/problem-ants/common-invasive-ants/white-footed-ants (Accessed 31 May 2017).

Pestnet. 2006. *Nipaecoccus nipae*. http://www.pestnet.org/Summariesof Message/ests/PestsEntities/Insects/ScalesMealybugs/Nipaecoccusnipae.Fiji.aspx (Accessed 25 Aug. 2017).

Quattrocchi, U. 2012. *World Dictionary of Medicinal and Poisonous Plants. Vol.1*. CRC Press, Boca Raton.

Quisumbing, E. 1951. *Medicinal plants of the Philippines*. Department of Agriculture and Natural Resources. Technical bulletin 16. Bureau of Printing, Manila. http://trove.nla.gov.au/work/8316997 (Accessed 7 Sept. 2017)

RADA (Rural Agricultural Development Agency). 2015. *Pink Hibiscus Mealybug.* https://www.rada.gov.jm/component/k2/item/688-pink-hibiscus-mealybug *(Accessed 6 June 2017)*.

Rao VP, 1951. *Iceryine* scale insects recorded from the Orient. *Indian Journal of Entomology* 2:39-66, 127-158.

Ravensdown. 2017. Rogor. https://www.ravensdown.co.nz/products/agrochemicals/rogor (Accessed 22 June 2017).

Rechcigl, J.E. and Rechcigl, N.A. (eds). 1998. *Biological and biotechnological control of insect pests*. CRC Press, Baca Raton.

Reeves, W. n.d. Pink Hibiscus Mealybug. *The Georgia Gardner* http://www.walterreeves.com/insects-and-animals/pink-hibiscus-mealybug/ (Accessed 12 May 2017),

Renvoize, S.A. 1975. *Icerya seycellarum* on Aldabra . Unpublished Royal Society Aldabra Research Station Report ALD/21 (75). 41pp.

Rodda, G.H., Fritts, T.H. and Conry, P.J. 1992. Origin and Population Growth of the Brown Tree Snake, *Boiga irregularis*, on Guam. *Pacific Science* 46(1): 46—57.

Rogers, H.S., HilleRisLambers, J., Fricke, E.C., Miller, R.H. and Tewksbury, J.J. 2017. Effects of an invasive predator cascade to plants via mutualism disruption. *Nature Communications* 8 (14557). doi:10.1038/ncomms14557. https://www.nature.com/articles/ncomms14557 (Accessed 6 August 2017).

RJR News. 2007. New infestation of pink mealy bug found. *RJR News* Dec. 22. http://rjrnewsonline.com/local/new-infestation-of-pink-mealy-bug-found (Accessed 6 June 2017)

Sarnaat, E.M. and Economo, E.P. 2012. *The Ants of Fiji*. UC Publications in Entomology. University of California Press, Berkeley. http://www.ucpress.edu/book.php?isbn=9780520098886 ISBN: 9780520955219

Schmaedick, M.A. 2007. Background on the Seychelles scale in American Samoa and possible introduction of the lady beetle *Rodolia pumila* from Tutuila Island to control scale on Ta'u Island. Land Grant Program, American Samoa Community College, American Samoa.

Serrano, M.S., Lapinte, S.L. and Meyerdirk, D.E. 2001. Attraction of males by virgin females of the mealybug *Maconellicoccus hirsutus*. *Journal of Environmental Entomology* 30 (2): 339-345.

SIF. 2017. Coccid monitoring. Seychelles Island Foundation. http://www.sif.sc/index.php?langue=eng&rub=28 (Accessed 19 July 2017).

Simberloff, D. 1995. Why do introduced species appear to devastate islands more than mainland areas? *Pacific Science* 49 (1); 87-97.

Simberloff, D., Martin, J.-L., Genovesi, P., Maris, V., Wardle, D.A., Aronson, J., Courchamp, F., Galil, B., Garcia-Berthou, E., Pascal, M., Pysek, P., Sousa, R., Tabbachi, E. and Vila, M. 2013. Impacts of biological invasions: what's what and the way forward? *Trends in Ecology & Evolution*, 28 (1): 58—66.

Staff Reporter. 2017. Upper Assam TEs under Scale insect threat. *The Sentinel* Sept. 13. http://sentinelassam.com/story/main-news/0/scale-pest-threat-to-upper-assam-tes/2017-09-13/1/320141#.WbigoROCzUI (Accessed 14 Sept. 2017)

Thaman, R.R. 1977. Plant resources of the Suva Municipal Market, Fiji. *Ethnomedicine* IV 1/2 (1976/77):23-62.

Thaman, R.R. 1982. Deterioration of traditional food systems, increasing malnutrition and food dependency in the Pacific Islands. *Journal of Food and Nutrition* 39(3):109-121.

Thaman, R.R. 1983. Urban gardening in Fiji: A direct means for sustainable national development. *Proceedings of the Fiji Society* 13:1-27.

Thaman, R.R. 1984. The poisoning of paradise: Pesticides, people, environmental pollution and increasing dependency in the Pacific Islands. *South Pacific Forum* 1(2):165-200.

Thaman, R.R. 1987. Urban agroforestry: The Pacific Islands and beyond. *Unasylva* 39(155):2-13.

Thaman, R.R. 1988. Health and nutrition in the Pacific Islands: Development or underdevelopment. *GeoJournal* 16(2):211-227.

Thaman, R.R. 1989. Agrodeforestation and the neglect of trees: Threat to the wellbeing of Pacific societies. *Ples: An Environmental Education Journal for the South Pacific Region* 5:48-64.

Thaman, R.R. 1993a. Pacific Island urban agroforestry. Chapter 7 in Clarke, W.C. and Thaman, R.R. (eds.), *Pacific Island agroforestry: Systems for sustainability*. United Nations University Press, Tokyo. Pp. 145-156.

Thaman, R.R. 1993b. One hundred Pacific Island agroforestry trees. In Thaman, R.R. and Clarke, W.C. (eds.), *Pacific island agroforestry: Systems for sustainability*. Prepared for the United Nations University, Tokyo, Japan. Geography Department. The University of the South Pacific, Suva. Pp. 216-266.

Thaman, R.R. 1995. Urban food gardening in the Pacific Islands: A basis for food security in rapidly urbanising small-island states. *Habitat International* 19 (2):209-224.

Thaman, R.R. 1999. *Wedelia trilobata*: *Daisy invader of the Pacific Islands*. IAS Technical Report 99/2. Institute of Applied Science, University of the South Pacific. 12pp + photographs.

Thaman, R.R. 2004. Urban gardening on the small islands of the Pacific. *Urban Agriculture Magazine* 13 (December): 12-14. (www.ruaf.org:)

Thaman, Randy 2011. Wedelia – daisy invader of Melanesia: The worst weed in the Pacific? *Melanesian Geo Magazine* May-Aug.: 6-12.

Thaman, R. R. 2011. The silent invasion of our islands. *Mai Life* 55 (Dec): 64-65.

Thaman, R.R. 2013a. Islands on the frontline against the winds and waves of global change: Emerging environmental issues and actions to build resilience in Pacific small island developing states (PSIDS). In Tsai, H.-M. (ed,), *2013 Proceedings of the IGU Commission on Islands International Conference on Island Development: Local Economy, Culture, Innovation and Sustainability*. National Penghu University, Makong, Penghu Archipelago Taiwan, October 1 – 5, 2013. Pp. 3-H-1-1 – 10.

Thaman, R.R. 2013b. Silent alien invasion of our islands and seas: A call for action against invasive alien species (IAS). In Tsai, H.-M. (ed,), *2013 Proceedings of the IGU Commission on Islands International Conference on Island Development: Local Economy, Culture, Innovation and Sustainability*. National Penghu University, Makong, Penghu Archipelago,Taiwan, October 1 – 5, 2013. Pp. 2-D-3-1 – 6.

Thaman, R. 2014. Agrodeforestation and the loss of agrobiodiversity in the Pacific Islands: A call for conservation. *Pacific Conservation Biology*. Special issue on Biodiversity conservation in the Pacific Islands of Oceania (eds. S. Jupiter and R. Kingsford). 20 (2): 13pp. (http://pcb.murdoch.edu.au).

Thaman, R.R., Fihaki, E. and T. Fong. 2013. *Plants of Tuvalu: Lākau mo mouku o Tuvalu.* University of the South Pacific, Press, Suva. 259 pp.

Thaman, R.R. with Gregory, M. and Takeda, S. 2012. *Trees of life: A guide to trees and shrubs of The University of the South Pacific*. The University of the South Pacific Press, Suva. 335 pp.

Thaman, R.R. and O'Brien, K. 2011. Caterpillar devastates *kanava* and undermines resilience to climate change in Tuvalu. *Mai Life* 50 (July): 56-57.

Tsatsia, H. and Jackson, G. 2016a. Taro alomae & bobone (001). Pacific Pests and Pathogens Fact Sheet 001. *Pestnet*. http://www.pestnet.org/fact_sheets/taro_alomae__bobone_001.htm

Tsatsia, H. and Jackson, G. 2016b. Bele (*Abelmoschus*) shoot borer (023). Pacific Pests and Pathogens Fact Sheet 023. *Pestnet*. http://www.pestnet.org/fact_sheets/bele_abelmoschus_shoot_borer_023.htm (accessed 25 Aug. 2017).

Tsatsia, H. and Jackson, G. 2016c. Spiraling whitefly (025). Pacific Pests and Pathogens Fact Sheet 025. *Pestnet*. http://www.pestnet.org/fact_sheets/spiralling_whitefly_025.htm (accessed 25 Aug. 2017).

Tsatsia, H. and Jackson, G. 2016d. Sooty moulds (051). Pacific Pests and Pathogens Fact Sheet 051. *Pestnet*. http://www.pestnet.org/fact_sheets/sooty_moulds_051.pdf

Tsatsia, H. and Jackson, G. 2016e. Coffee brown scale. Pacific Pests and Pathogens Fact Sheet 066. *Pestnet*. http://www.pestnet.org/fact_sheets/coffee_brown_scale_066.htm.

UNEP. 2014. *Emerging issues for Small Island Developing States. Results of the UNEP/UN DESA Foresight Process*. United Nations Environment Programme (UNEP), Nairobi, Kenya.

Van Driesche, R.G., Carruthers, R.I., Center, T., Hoddle, M.S., Hough-Goldstein, J., Morin, L., Smith, L., Wagner, D.L., Blossey, B., Brancatini, V., Casagrande, R., Causton, C.E., Coetzee, J.A., Cuda, J., Ding, J.; Fowler, S.V., Frank, J.H., Fuester, R., Goolsby, J., Grodowitz, M., Heard, T.A., Hill, M.P., Hoffmann, J.H., Huber, J., Julien, M., Kairo, M.T.K., Kenis, M., Mason, P., Medal, J., Messing, R., Miller, R., Moore, A., Neuenschwander, P., Newman, R., Norambuena, H., Palmer, W.A., Pemberton, R., Perez-Panduro, A., Pratt, P.D., Rayamajhi, M., Salom, S., Sands, D., Schooler, S., Schwarzländer, M., Sheppard, A., Shaw, R., Tipping, P.W. and van Klinken, R.D. 2010. Classical biological control for the protection of natural ecosystems. *Biological Control* 54: 52—533. Publications from USDA-ARS / UNL Faculty. 883. http://digitalcommons.unl.edu/usdaarsfacpub/883 (Accessed 22 August 2017)

Van Ripper III, C, van Ripper, S.G., Lee Goff, M, and Laird, M. 1986. The epizootiology and ecological significance of malaria in Hawaiian land birds. *Ecological Monographs* 56: 127-44.

Vargas, R.I,, Leblanc, L., Putoa, R. and Eitam, A. 2007. Impact of introduction of *Bactrocera dorsalis* (Diptera: Tephritidae) and classical biological control releases of *Fopius arisanus* (Hymenoptera: Braconidae) on economically important fruit flies in French Polynesia. *Journal of Economic Entomology* 100: 670 – 9..

Vaqalo, M., Lonalona, M., Panapa, S. and Khan, F. 2014. Yellow crazy ants and fruit fly surveys in Tuvalu (25th October to 4th November 2014). Secretariat of the Pacific Community, Suva and Plant Protection and Quarantine Services, Department of Agriculture , Ministry of Natural Resources and Lands, Funafuti. http://piat.org.nz/uploads/PIAT_content/pdfs/Vaqalo%20et%20al_2014.pdf (Accessed 8 August 2017).

Walker, A.K. and Deitz, L.L. 1979. A review of entomophagous insects in the Cook Islands. *New Zealand Entomologist* 7 (1): 70—82.

Ward, D.F. and Wetterer, J.K. 2006. Checklist of the Ants of Fiji (Hymenoptera: Formicidae). In Evenhuis, N.L. and Bickel, D.J. (eds.). *Fiji Arthropods III. Bishop Museum Occasional Papers* 85: 23–47.

Warner, J. and Scheffrhan, R.H. 2002 (reviewed 2016). White-footed ant. Featured creatures: Entomology & Nematology. University of Florida, http://entnemdept.ufl.edu/creatures/urban/ants/white-footed_ant.htm (Accessed 9.5.17)

Warner, J., Scheffrhan, R.H and Cabrera, B. 2002. White-Footed Ant, *Technomyrmex difficilis* (=albipes) Forel (Insecta: Hymenoptera: Formicidae: Dolichoderinae). Department of Entomology and Nematology, University of Florida and IFAS Extension. .Gainesville http://edis.ifas.ufl.edu.

Waterhouse DF (1991) Possibilities for the biological control of the breadfruit mealybug, *Icerya aegyptiaca*, on Pacific Atolls. *Micronesica* (Suppl. 3):117–122.

Watson, G.W, 2016. *Planococcus citri* (citrus mealybug). *CABI Invasive Species Compendium* http://www.cabi.org/isc/datasheet/45082 (Accessed 29 August 2017)

Weems, H.V., Heppner, H.P., Nation, J.L. and Fasula, T.R. 1999 (revised 2012). Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Insecta: Diptera; Tephritidae) *Featured Creatures*: *Entomology & Nematology*. Entomology circulars 21 and 303. University of Florida http://entnemdept.ufl.edu/creatures/fruit/tropical/oriental_fruit_fly.htm (Accessed 29 Oct. 2013).

Weissling, T.J. and Howard, F.W. 2017. Cycad aulacaspis scale: *Aulacaspis yasumatsui* Takagi (Insecta: Hemiptera: Sternorrhyncha: Diaspididae). *Featured creatures*. UF/IFAS, University of Florida http://entnemdept.ufl.edu/creatures/orn/palms/cycad_scale.htm

Wetterer JK. 2008. *Technomyrmex difficilis* (Hymenoptera: Formicidae) in the West Indies. *Florida Entomologist* 91: 428-430.

Wetterer, J.K. 2013. Worldwide spread of the difficult white-footed ant, *Technomyrmex difficilis* (Hymenoptera: Formicidae). *Myrmecological News* 18:93—97.

Wilson, M. 2013. Fruit fly outbreak disastrous. *Cook Islands News* 29 May. http://www.cookislandsnews.com/2013/May/Wed29/environment.htm (accessed 23 July 2013).

Whistler, W.A, 1980. *Coastal flowers of the tropical Pacific*. The Pacific Tropical Botanical Garden, Lawai, Kauai, Hawaii.

Whistler, W.A. 1994. *Wayside plants of the islands: A guide to the lowland flora of the Pacific Islands*. Isle Botanica, Honolulu.

Whistler, W.A. 2000. *Tropical ornamentals: A guide*. Timber Press, Portland.

Whistler, W.A. 2009. *Plants of the canoe people: An ethnobotanical voyage through Polynesia*. National Tropical Botanical Garden, Kawai, Kaua'i.

Whitehorn, P. R., O'Connor, S., Wackers, F. L. and Goulson, D. 2012. Neonicotinoid pesticide reduces bumble bee colony growth and queen production. *Science* 336 (6079): 351–2. ISSN 0036-8075. PMID 22461500. doi:10.1126/science.1215025.

Williams D.J, 1985. *Australian mealybugs.* British Museum (Natural History), London.

Williams D.J, and Watson G.W, 1990. *The scale insects of the tropical South Pacific region. Part 3: the soft scales (Coccidae) and other families*. CAB International, Wallingford, UK.

Williamson, M. 1981. *Island populations.* Oxford University Press, Oxford.

Wilson, E.O. and Taylor, R.W. 1967: Ants of Polynesia. *Pacific Insects Monograph* 14: 1-109.

Wilson, M. 2013. Fruit fly outbreak disastrous. *Cook Islands News* 29 May. http://www.cookislandsnews.com/2013/May/Wed29/environment.htm (accessed 23 July 2013).

Yamamoto, I. 1999. Nicotine to Nicotinoids: 1962 to 1997. In Yamamoto and Casida, J. (eds.), *Nicotinoid insecticides and the nicotinic acetylcholine receptor*. Springer-Verlag, Tokyo. pp. 3–27. ISBN 443170213X.

Appendices

Appendix I

Families, genera and species of cultivated and wild plants affected by symbiotic infestations of WFA along with SS and/or CMB, ACS, PHM, scales and other insects such as aphids based on field studies in Suva and other selected locations on Viti Levu Island, Fiji by R. Thaman from May to August 2017. Common and Fijian names (including Hindi names) are, when available, provided in bold for some local indigenous and culturally important plants. Ferns and then Gymnosperms are listed first, followed by Dicotyledons and Monocotyledons (Notes: Families, genera and species are listed in the approximate order of severity of infestation and number of genera and species infested; * indicates that a given genus or family, e.g. Hibiscus may be represented by a number of distinct cultivars)(Appendix II is a detailed species-by-species listing including approximate order of levels and incidences of infestation along with full scientific, common and vernacular Fijian (Fiji and Indo-Fijian) names, levels of observed infestations, parts infested and number of locations at which infestations were observed).

FERNS AND FERN ALLIES (PTERIDOPHYTES) (2 sp. from 2 genera and 2 families)
Aspidiaceae (Rounder Sori Fern Family) = 1 genus, 1 spp.

- *Tectaria latifolia,* black-stiped fern, **otaloa**

Nephrolepidiaceae (Sword Fern Family) – 1 genus, 1 sp.

- *Nephrolepis biserrata,* sword fern, **digi**

GYMNOSPERMS (2 sp. from 1 genus and 1 family)
Cycadaceae (Cycad Family) - 1 genus, 2 spp.

Cycas: queen sago palm, queen cycad, **logologo** *(C. seemannii)*; king sago palm, Japanese sago plam, Japanese cycad *(C. revoluta)* (2)

DOCOTYLEDONS 217 spp. from 137 genera and 47 families)
Rutaceae (Citrus or Rue Family) - 4 genera, 12 spp.

- *Citrus:* limes *(Citrus aurantifolia)*; mandarin orange *(C. reticulata)*; lemon *(C. x limon)*; pomelo, **moli kana** *(C. maxima)*; rough lemon *(C. x jambhiri)*; orange *(Citrus x sinensis)*; sour orange *(C. aurantium)*; calamondin orange *(C. mitis or C. x Fortunella)*(8)
- *Euodia hortensis*, island musk, **uci** (1)
- *Murraya*: curryleaf, curry tree, Indian bayleaf, **tejpatti** *(M. koenigii)*; orange jessamine *(M. paniculata)* (2)
- *Micromelum minutum*, limeberry, micromelum, **qilqila, sasaqilu, tavolali** (1)

Moraceae (Mulberry or Fig Family) - 4 genera, 10 spp.

- *Ficus:* wide range of figs, including two Fiji endemic figs, **losilosi** *(F. barclayana)* and Fiji fig, **lolō** *(F. vitiensis)*(both important medicinal plants and the latter an emergency food plant); sacred banyan, bo tree *(F. religiosa)*(sacred plant of Hinduism and Buddhism); climbing fig *(F. pumila)*; dyer's fig, **baka, nunu** (Ficus tinctoria (an important medicinal plant; small-leaved fig, **baka ni Viti** (F. obliqua) (6)
- Artocarpus: breadfruit and jackfruit *(A. altilis and A. heterophyllus)*(both important staple food trees in Fiji) (2)
- *Broussonetia papyrifera,* paper mulberry, **masi**, one of Fiji's most important handicraft plants (1)
- *Morus alba:* white mulberry, **tut** (1)

Malvaceae (Mallow or Hibiscus Family) - 7 genera, 17 spp, or distinct hybrids*

- *Hibiscus:* ornamental hibiscuses, **senitoa** (*H. rosa-sinensis* and at least 6 distinct hybrid cultivars, *H. x hybridus*); changeable mallow *(H. mutabilis)*, coral hibiscus, split-petalled hibiscus *(H. schizopetalus)*; beach hibiscus, **vau, vauleka** (H. tiliaceus)(9)
- *Abelmoschus:* okra, roselle and hibiscus spinach or **bele** *(Abelmoschus esculentus, A. sabdariffa and A. manihot)*(all important food plants in Fiji (3)
- *Thespesia populnea,* Thespian's tree, portia tree, milo **mulomulo** (1)
- *Abutilon* x hybrid, mallow (1)
- *Malvaviscus penduliflorus,* Turk's cap, sleeping hibiscus (1)
- *Urena lobata,* Caesarweed, Cuba jute, pink hibiscus bur (1)
- *Gossypium barbadense,* sea island cotton, **vauvau ni Viti** (1)

Rubiaceae (Coffee or Madder Family) - 5 genera, 14 spp.

- *Ixora:* red ixora, **sinu ni vavalagi** *(I. coccinea);* Chinese ixora *(I. chinensis)*; giant red ixora *(I. casei)*; yellow ixora, **sinu ni vavalagi** *(I. lutea)*, fragrant white ixora, **sinu ni vavalagi** *(I. finlaysoniana)*; orange ixora *(I. javanica)*; pink ixora *(I. siamea)*(7)
- *Gardenia:* Tahitian gardenia, **tiare Tahiti, jale ni Taiti** *(Gardenia taitensis)*(national flower of the Cook Islands and Tahiti); common gardenia, cape jasmine, **jale ni vavalagi** *(G. jasminoides)*; Hutchinson's gardenia, **jale** *(G. hutchinsonii)*(endemic gardenia)(3)
- *Mussaenda:* white Mussaenda *(M. philippica)*; pink mussaenda *(M.erythrophylla x philippica)*(2)
- *Coffea arabica*, coffee, **kofi** (1)
- *Pentas lanceolata,* Egyptian starcluster (1)

Fabaceae (Legume, Bean or Pea Family) - 22 genera, 27 spp.

- *Bauhinia:* purple orchid tree *(B. variegata)*; pink bauhinia, pink orchid tree *(B. monandra)* (2)
- *Vigna:* longbean, asparagus bean *(V. sesquipedalis)*; beach pea, **drautolu** *(V. marina)* (2)
- *Flemingia:* bigleaf flemingia, apa apa *(F. microphylla)*; wild hops *(F. strobilifera)* (2)
- *Calliandra:* Pink powderpuff, Surinam calliandra *(C. surinamensis)*, calliandra, red calliana *(C. calothyrsus)* (2)

- **Cassia:** golden shower tree *(C. fistula)*, pink-and-white shower tree *(C. javanica)* (2)
- *Tamarandus indicus,* tamarind, **imli** (1)
- *Arachis hypogaea*, peanut, groundnut (1)
- *Phaseolus vulgaris,* French bean, haricot bean (1)
- *Psophocarpus tetragonolobus,* winged bean (1)
- *Arachis hypogaea,* peanut, groundnut, **vinati** (1)
- *Samanea saman,* raintree, monkeypod, **vaivai ni vavalagi, vaivai moce, sirsa** (1)
- *Inocarpus fagifer,* Tahitian chestnut, **ivi** (1)
- *Intsia bijuga,* Pacific teak, ipil-ipil, **vesi** (1)
- *Centrosoma pubescens,* centro (1)
- *Derris trifoliata,* fish-poison vine (1)
- *Senna siamea,* Siamese cassia, kassod tree (1)
- *Peltophorum pterocarpum,* yellow poinciana, yellow flamboyant, copperpod (1)
- *Cynometra insularis,* **cibicibi, moivi** (1)
- *Pterocarpus indicus,* Burmese rosewood, Amboyna wood, red sandalwood (1)
- *Milletia pinnata,* beach walnut, pongam, **vesiwai** (1)
- *Gliricidia sepium,* Mother-of-cocoa, Mexican lilac, quickstick, **bainicagi** (1)
- *Adenanthera pavonina,* red-bead tree, **lera, diridamu** (1)

Myrtaceae (Myrtle Family) - 3 genera, 9 spp.
- *Psidium:* guava *(P. guajava)* (one of the most seriously infested species); strawberry guava *(P. cattleyanum)*(2)
- *Syzygium:* **leba** *(S. neurocalyx)*; **misimisi** *(S. corynocarpum)*; rose apple, Java apple *(S. jambos)*; java plum, jabolan, **kavika ni vavalagi** *(S. cumini)*; Malay apple, **kavika** *(S. malaccense)*; **yasi, lutulutu?** *(Syzygium cf gracilipes* (6)
- *Eugenia uniflora,* Surinam cherry (1)

Annonaceae (Custard Apple Family) - 3 genera, 7 spp.
- *Annona:* soursop *(A, muricata)*; sweetsop or sugar apple *(A. squamosa)*; bullock's heart, custard apple, **uto ni bulamakau** *(A. reticulata)*; pond apple, **utonibulumakau** *(A. glabra)* (4)
- *Polyalthia: P. longifolia*, sorrowful tree, **ashoka**: P. laddiana, **mocelolo** (2)
- *Canaga odorata,* ylangylang or perfume tree, **makosoi** (1)

Euphorbiaceae (Spurge Family) - 8 genera, 12 spp.
- *Acalypha:* Chenille plant, rod-hot poker (A. hispida); copperleaf, beefsteak plant (A. wilkesiana); picotte aclaypha *(A. wilkesiana f. circinata* (3)
- *Euphorbia:* poinsettia *(E. cyathophora)*; Fiji spurge, **vasa damu** (E. fidgiana) (2)
- *Manihot:* cassava, manioc, **tavioka** *(M. esculenta*, tree cassava *(M. carthagenensis ssp. glaziovii)* (2)
- *Macaranga segunda,* Macaranga, **davo, velutu** (1)
- *Codiaeum variegatum*, croton, **sacasaca** (1)
- *Endospermum macrophyllum,* whitewood, **kauvula** (1)
- *Aleurites moluccana,* candlenut, **lauci, sikeci** (1)
- *Excoecaria agallocha,* blinding tree, **sinu gaga** (1)

Solanaceae (Nightshade Family) - 5 genera, 11 spp.
- *Solanum:* eggplant, **baigan** *(S. melongena)*; prickly solanum, **soni** *(S. torvum)*; tomato *(S. lycopersicon;* black nightshade, **boro ni veiwere, malasou, moukaiya** *(S. americanum)* (4)
- *Capsicum:* chili, tabasco, **rokete, mirchi** *(C. frutescens);* annual chili peppers, **mircha** *(C. annuum vars.)*; sweet capsicum, bell pepper *(C. annuum var, annuum)*; *ornamental black chili (C. annuum var,)* (4)
- *Brunfelsia paucifolia,* yesterday-today-and-tomorrow (1)
- *Brugmansia x candida*, angel's trumpet (1)
- *Cestrum nocturnum,* night-blooming jasmine, night jessamine, **caucaunibogi** (1)

Lauraceae (Laurel Family) – 1 genus, 1 sp.
- *Persea americana,* avocado, **pea** (1)

Anacardiacee (Cashew Family) - 3 genera, 3 spp.
- *Mangifera indica,* mango, **maqo, am** (1)
- *Spondias dulcis,* Polynesian vi-apple, **wi, amra** (1)
- *Dracontomelon vitiense,* dragon plum, **tarawau** (1)

Acanthaceae (Acanthus Family) – 9 genera, 10 spp.
- *Pachystachys:* yellow shrimp plant *(P lutea)*; cardinal's guard *(P. spicata)* (2)
- *Hemigraphis alternatus,* metal leaf (1)
- *Sanchezia speciosa,* sanchezia, firefingers (1)
- *Blechum pyramidatum,* Browne's blechum (1)
- *Asystasia salicifolia,* willow-leaf Asystasia (1)
- *Eranthemum pulchellum,* blue eranthemum, blue sage (1)
- *Odontonema tubiforme,* firespike (1)
- *Pseuderanthemum carruthersii* var. *reticulatum,* yellow-veined false eranthemum, El Dorado (1)
- *Thunbergia grandiflorum* Bengal clockvine, skyflower (1)

Cucurbitaceae (Gourd or Cucurbit Family) – 5 genera, 5 spp.
- *Luffa acutangula,* ridged gourd, angled loofa, **taroi** (1)
- *Coccinia grandis*, ivy gourd, **kudru** (1)
- *Cucurbita moschatus,* pumpkin, **wavukeni, kadadu** (1)
- *Citrullus lanatus,* watermelon, **mereni, tarbuj** (1)
- *Cucumis sativus*, cucumber, **kukaba** (1)

Goodeniaceae (Goodenia Family) - 1 genus, 1 sp.
- *Scaevola taccada*, beach half-flower, Scaevola, **vevedu** (1)

Piperaceae (Pepper Family) – 1 genus, 3 spp.
- *Piper:* spiked pepperbush, matico, **yaqona ni Onolulu** *(P. aduncum)* (1); hoja santa, sacred leaf, Mexican pepperleaf, **yaqona ni Hauai** *(P. aietum)*; betel pepper, **paan**, *P betle,* (1)

Convolulaceae (Morning-glory Family) – 2 genera, 5 spp.
- *Merremia:* Hawaiian woodrose, yellow morning-glory *(Merremia tuberosa);* merremi *(M. peltata)*(2)
- *Ipomoea:* sweet potato, **kumala** *(I. batatas)*; bush morning (*I. carnea* ssp. *fistulosa*) glory blue morning-glory *(I. indica)*(2)

Lythraceae (Loosestrife Family) - 3 genus, 4 spp.
- *Lagerstroemia: L. indica,* crepe myrtle; *L. speciosa,* pride-of India, queen's crepe myrtle (2)
- *Cuphea hyssopifolia,* Mexican heather (1)
- *Punica granatum,* pomegranate, **anar** (1)

Casuarinaceae (Casuarina Family) - 2 genera, 2 spp.
- *Gymnostoma vitiense,* **velau** (2)
- *Casuarina equisetifolia,* casuarina, she oak, ironwood, **nokonoko** (1)

Verbenaceae (Verbena or Vervain Family) - 3 genera, 7 spp.
- *Clerodendrum:* Wallich's clerodendrum *(C. wallichii);* Philippine glorybower, staburst *(P. quadriloculare);* pagoda flower *(C, paniculatum);* bleeding heart *(C. thomsonae);* Chinese glorybower *(C. chinense)*(5)
- *Duranta erecta,* golden dewdrops (1)
- *Vitex trifolia,* blue vitex, **dralakaka** (1)

Lamiaceae (Mint Family) – 3 genera, 4 spp.
- *Ocimum:* sweet basil *(O. basilicum);* holy or sacred nbasil, **tulsi** *(O. tenuiflorum)* (2)
- *Congea tomentosa,* wooly congea, shower orchid (1)
- *Tectona grandis,* teak, **tiki** (1)

Oxalidaceae (Oxalis Family) – 2 genera, 4 spp.
- *Averrhoa:* carambola, **wi ni Jaina, wi ni Idia, kamrakh?** *(A. carambola)*; belimbi, cucumber tree *(A. belimbi)*(2)
- *Oxalis:* Pink woodsorrel, lilac oxalis *(O. debilis)*; Barrelier's woodsorrel *(O. barrelieri),*

Lecythidaceae (Paradise Nut or Brazil Nut Family) – 2 genera, 3 spp.
- *Couroupita guianensis,* cannonball tree (1)
- *Barringtonia:* fishpoison tree, **vutu rakaraka** (B. asiatica); cutnut, edible barringtonia, **vutu kana, vutu vala** (B. edulis)

Boraginaceae (Borage or Forget-me-not Family) – 1 genus, 2 spp.
- *Cordia:* Assyrian plum, **lasora** *(C. myxa)*: beach cordia, **nawanawa** *(C. subcordata)*(2)

Clusiaceae (Garcinia or Clusia Family) – 2 genera, 2 spp.
- *Garcinia sessilis,* heilala, **seilala** (1)
- *Calophyllum inophyllum*, Alexandrian laurel, tomano, beautyleaf, **dilo** (1)

Asteraceae (Aster, Daisy, Composite or Sunflower Family) – 7 genera, 7 spp.
- *Synedrella nodiflora,* nodeweed (1)
- *Eleutheranthera ruderalis,* ogiera (1)
- *Ageratum conyzoides,* goatweed, **botebotekoro** (1)
- *Mikania macrantha,* mile-a-minute, **wabosucu** (1)
- *Cyanthillium cinereum,* little ironweed, **kaukamea** (1)
- *Crassocephalum crepidioides*, redflower ragleaf; thickhead (1)
- *Youngia japonica,* Oriental false hawksbeard (1)

Apocynaceae (Dogbane Family) – 2 genera, 3 spp.
- *Alyxia stellata,* maile, **vono** (1)
- *Plumeria:* white evergreen frangipani, **bua Solomoni** *(P. obtusa)*; red frangipani, common plumeria, **bua ni vavalagi** *(P. rubra)* (2)

Sapotaceae (Sapodilla Family) – 1 genera, 1 sp.
- *Manilkara zapota,* sapote (1)

Thymelaeaceae (Daphne or Mezereum Family) - 1 genus, 1 spp.
- *Phaleria disperma,* **sinu ni baravi, mataivi** (important indigenous coastal and cultivated plant used in garlands and to scent coconut oil) (1)

Sapindaceae (Soapberry Family) - 3 genera, 3 spp.
- *Acer cf palmatum* palmate maple, Japanese maple (1)
- *Filicium decipiens,* fern tree, fern leaf (1)
- *Pometia pinnata,* island lychee, oceanic lychee, **dawa** (1)

Phyllanthaceae (Phyllanthus Family) - 3 genera, 3 spp.
- **Flueggea flexuosa,** poumuli
- *Phyllanthus tenellus,* Mascarene Islands leaf-flower
- *Bischofia javanica,* Java cedar, bishop's wood, **koka** (1)

Combretaceae (White Mangrove or Indian Almond Family) - 2 genera, 2 sp.
- *Quisqualis indica,* Rangoon creeper, **sinukakala** (1)
- *Terminalia catappa,* tropical almond, **tavola** (1)

Araliaceae (Aralia Family) - 2 genera, 4 spp.
- *Polyscias:* fern-leaf aralia, angelica *(P. filicifolia)*, **dalidali:** guilfoyle hedge panax, **danidani** *(P. guilfoylei)*, bigleaf panax, **danidani** *(P. scutellaria)*(3)
- *Schlefflera actinophylla,* Queensland umbrella tree, octopus tree (1)

Rosaceae (Rose Family) - 1 genus, 1 sp.
- *Rosa damascene,* damask rose (1)

Santalaceae (Sandalwood Family) - 1 genus, 1 sp.
- *Santalum yasi,* Fiji sandalwood, **yasi, yasi boi** (1)

Urticaceae (Nettle Family) - 2 genera, 2 sp.
- *Boehmeria microphylla,* false nettle (1)
- *Pilea nummularifolia,* creeping Charlie (1)

Moringaceae (Horseradish Tree Family) - 1 genus, 1 sp.
- *Moringa oleifera,* horseradish tree, drumstick tree, **saijan, boto ni Idia**

Chrysobalanaceae (Coco Plum Family) - 1 genus, 1 sp.
- *Atuna racemosa,* **makita** (1)

Bignoniaceae (Trumpet-creeper or Bignonia Family) - 1 genus, 1 sp.
- *Mansoa hymenaea,* garlic vine (1)

Gesneriaceae (Gesneria Family) - 1 genus, 1 sp.
- *Chrysostemis pulchella,* dozakie (1)

Amaranthaceae (Amaranth Family) - 1 genus, 1 sp.
- *Amaranthus hybridus,* amaranth spinach, **tubua, chauraiya, moca** (1)

Apiaceae (Celery Family) - 1 genus, 1 sp.
- *Eryngium foetidum,* culantro, Mexican coriander, long coriander, **jungle dhaniya** (1)

Basellaceae (Basella or Madeira Vine Family) – 1 genus, 1 sp.
- *Basella alba,* Malabar spinach, climbing spinach, **poi** (1)

Polygonaceae (Buckwheat Family) – 1 genus, 1 sp.
- *Antigonon leptopus,* Mexican creeper, coral vine, beebush (1)

Passifloraceae (Passionaflower Family) - 2 genera, 2 sp.
- *Turnera ulmifolia,* yellow alder (1)
- *Passiflora suberosa,* corkystem passionflower (1)

Caricaceae (Papaya Family) – 1 genus, 1 sp.
- *Carica papaya,* papaya, **weleti** (1)

Vitaceae (Grape Family) – 1 genus, 1 sp.
- *Vitis* sp., grapevine, grape (1)

MONOCOTYLEDONS (71 species from 46 genera and 15 families)

Arecaceae (Palm Family) – 17 genera, 20 spp.
- *Pritchardia pacifica,* Fiji fan palm, Pacific fan palm, **niusawa** (1)
- *Chrysalidocarpus lutescens*, golden can palm (1)
- *Ptychosperma macarthuri,* Macarthur palm (1)
- *Caryota* sp., fishtail palm (1)
- *Sabal:* bush palmetto *(Sabal minor)*, palmetto, thatch palm *(S. palmetto)*(2)

- *Cocos nucifera*, coconut palm, **niu** (1)
- *Livistona chinensis*, Chinese fan palm, shower palm (1)
- *Rhaphis:* lady palm (R. excels); dwarf lady palm (R. subtilis) (2)
- *Licuala grandis,* fringed fan palm (1)
- *Areca:* betelnut palm, **niu Solomone** *(A. catechu)*; orange crownshaft palm *(Areca vestiaria* (2)
- *Bactris gasipaes,* peach palm (1)
- *Veitchii merrillii,* Manila palm, Christmas palm (1)
- *Pelagodoxa henryana,* Marquesas palm (1)
- *Pinanga coronata,* ivory cane palm (1)
- *Bismarckia nobilis,* Bismarck palm (1)
- *Bactris gasipaes,* peach palm, pejibaye (1)
- *Acrocomia aculeata,* macaw palm, grugru palm, Macaúba palm
- *Metroxylon vitiense* Fiji sago palm, **soga** (1)

Araceae (Arum Family) - 10 genera, 14 spp.
- *Anthurium andreanum,* anthurium, tail flower, flamingo flower (1)
- *Colocasia esculenta,* taro, **dalo** (1)
- *Xanthosomoa:,* belembe, Tahitian spinach *(X. brasiliensis);* cocoyam, yautia, American taro, arrowhead leaf elephant ear *(X. sagittifolium* (2)
- *Alocasia:* giant taro, **via mila** *(A. macrorrhizos);* Chinese taro *(A. cucullata)*(2)
- *Syngodium podophyllum,* arrowhead vine, syngodium (1)
- *Aglaonema commutatum,* Chinese green (1)
- *Epipremnum:* pothos aureus, taro vine, devil's ivy *(E. aureum);* centipede tongavine, **yalu** *(E. pinnatum)*(2)
- *Monstera deliciosa,* Swiss cheese plant (1)
- *Philodendron cf scandens,* heart-leaf philodendron; philodenron cultivar (2)
- *Spathophyllum wallisii* x 'Clevelandii', white sails, peace flower (1)

Heliconiaceae (Heliconia Family) – 1 genus, 10 spp.
- *Heliconia:* hanging lobster claw heliconia *(H. rostrata);* parakeet heliconia *(H. psitticorum,);* golden lobster claw heliconia *(H. lathispatha);* "Golden Torch" *(H. psitticorum x H. lathispatha);* heliconia cv, Roberto-Burle-Marx *(H. hirsuta);* lobster claw Heliconia, firebird heliconia *(H. bihai);* Caribbean heliconia *(H. caribaea);* Jacquin's Heliconia *(H. caribaea x bihai* cv, 'Jacquinii'); hanging red heliconia *(H. collinsiana);* lobster claw heliconia *(H. stricta)* (7)

Zingiberaceae (Ginger Family) – 3 genera, 6 spp.
- *Alpinia: A. purpurata,* red ginger, **cevuga damu;** *A. vittata,* variegated ginger (2)
- *Hedychium;* pink ginger *(H. coccineum);* white ginger **dalasika** *(H. coronarium)* (2)
- *Zingiber:* common ginger *(Z. officinale);* bitter ginger, shampoo ginger, **cagolaya** *(Z. zerumbet)* (2)

Marantaceae (Arrowroot Family) – 1 genus, 3 spp.
- *Calathea:* rattlesnake plant, **bati ni tadruku** *(C. crotalifera);* pinstripe calathea *(C. ornata);* zebra plant, zebra calathea *(C. zebra)* (3)

Musaceae (Banana Family) – 1 genus, 4 spp./cultivars
- *Musa* AAA Group, banana cultivar, **jaina** (1)
- *Musa* AAB Group, Pacific plantain, **vudi** (1)
- *Musa* AB Group, ladyfinger banana, **liga ni marama** (1)
- *Musa* velutina, pink banana, hairy banana (1)

Costaceae (Costus of Spiral Flag Family) – 2 genera, 2 spp.
- *Cheilocostus speciosus,* crepe ginger (1)
- *Costus woodonii,* scarlet spiral flag (1)

Agavaceae (Agavae Family) – 1 genus, 1 sp
- *Cordyline fruticosa,* ti-plant, **vasili** (1)

Pandanaceae (Pandanus Family) – 1 genus, 2 spp.
- *Pandanus:* pandanus, screwpine, **vadra**)*Pandanus tectorius;* Joske's pandanus, **kukuwalu** *(P. joskei)*(2)

Poaceae (Grass Family) – 2 genus, 2 sp.
- *Bambusa vulgaris,* common bamboo, **bitu ni vavalagi**
- *Saccharum officinarum,* sugarcane, **dovu** (1)

Commelinaceae (Dayflower of Spiderwort Family) – 2 genera, 2 spp.
- *Commelina diffusa,* dayflower, **wa bulobula** (1)
- *Tradescantia zebrina,* wandering Jew, inch pant (1)

Cannaceae (Canna Family) – 1 genus, 1 sp.
- *Canna indica,* Indian shot (1)

Iridaceae (Iris Family) – 1 genus, 1 sp.
- *Trimezia martinicensis,* walking iris 1)

Dioscoreaceae (Yam Family) – 1 genus, 1 sp.
- *Dioscorea nummularia,* Pacific yam, **tivoli** (1)

Asparagaceae – 1 genus, 1 sp.
- *Dracaena fragrans,* fragrant dracaena, cornstalk dracaena, dragon flower, **vasi-li ni vavalagi** (1)

Appendix II

Plant families, genera and species affected by DFA, SS, PHM, CMB and/or other mealybugs, scale insects, other sapsucking insects or other pathogens infestations in Fiji based on field studies by R. Thaman from May—September 2017. Ferns and fern allies and gymnosperms are listed first followed by dicotyledons and monocotyledons (Note: the deliberately introduced mealybug destroyer or mealybug ladybird *(Cryptolaemus montrozieri)*, a notorious predator of mealybugs and scale insects, is also listed with hostplants on which it was observed and photographed)

Key.

1. Under species: 1) * indicates species (e.g., *Hibiscus rosa-sinensis*) that are affected by PHM, whereas all other species are affected by SS, the main active invasive mealybug/ scale and or other sap-sucking insects tended by WFA; 2) E = endemic Fiji species, I = indigenous species; A = aboriginal introduction, with all other species being considered to be non-indigenous post-European-contact introductions into Fiji.

2. Under common names: 1)The common English or other widely recognized names listed followed by local indigenous Fijian or Indian names for a given plant.

3. Under Inf. Lev. (Infestation Level), which has been assessed in terms of both the level of infestation of individual plants and the frequency it is seen in study areas): H = high, M = medium, L = low or incidental, A = ants only.**Under Pts Inf (parts infested):** Bd = buds, Br = branches, Fl = flowers, Fr = fruit; Fs = flower spathe/ stalk/cluster; Lm = leaf mid-vein, Ln = leaf node, Ls = leaf sheath; Lv = leaves,; Ps = pseudostem (bananas); Pt – petiole, Sc – found along with another scale insect; Sp = spathe; St = stem or stalk;, Tb = terminal buds, Tr = trunk, u = underside of leaves, t = topside of leaves, y = young leaves.

4. Under IAS (Invasive Alien Species responsible for infestation along with WFA): ACS - Asian cycad scale *(Aulacaspis yasumatsui);* APH = aphids (Aphididae); ASB = *Ablemoschus* (bele) shoot borer *(Earias vittella);* BMB = breadfruit mealy bug *(Icerya aegyptiaca);* BSM = black sooty mould (*Capnodium* and *Tripospermum* spp. plus others); CBS = coffee brown scale *(Saisettia coffaea)*; CMB - Coconut mealybug *(Nipaecoccus nipae.);* CS = circular scale *(Chrysomphalus aonidum);* CTM – citrus mealybug *(Planococcus citri);* LYM = longtailed mealybug *(Pseudococcus longispinus);* MBD = mealybug destroyer or mealybug ladybird *(Cryptolaemus montrouzieri);* NS = nigra scale *(Parasaisettia nigra);* PHM = Pink hibiscus mealybug *(Maconellicoccus hirsutus);* PMB = papaya mealybug *(Dysmicoccus brevipes)*; PR = Plumeria or frangipani rust *(Coleospermum plumeriae);* SBS = Soft bamboo scale *(Bambusaspis bambusae);* SS = Seychelles scale *(Icerya seychellarum);* STS = stellate scale *(Ceroplastes stellifera);* SWF = Spiralling whitefly *(Aleurodicus disperses);* UKS = unknown scale; YA = yellow aphid (ID unknown)

5. Under Locations: BH = Beach House, CS = Colo-i-Suva; Do = Domain, Suva; DS = Drew St. compounds, USP DW – Dick Watling's residence, Princes Rd.; Fs = Flagstaff; Suva; USP; GR = Gecko Resort, Nadroga; Gv = Governors Restaurant, Suva; KR = Khalsa Rd., Suva; KS = Knolly's St., Suva; La = Lami; LB = Laucala Beach Estate; LV = Linikoni Vakauta's compound, Service St.; MD = Mac Donalds, Raiwai; Mk = Muanikau; MR – McGregor Rd, Suva; MS = My Suva Picnic Park, Muanikau; NA = Nadi Airport; Na – Nasese, Suva; NF – National Food and Nutrition Centre and National Trust of Fiji Compounds, Suva; NR = Nailuva Road, Suva; PR = Princes Rd, Suva PTC = Pacific Theological College, Suva; QED – Queen Elizabeth Drive; RG = Raffles Gateway Hotel, Nadi Airport; RR = Rifle Range, Suva; RS = Rewa St., Suva; RT– residence, R. Thaman, Suva; Rw = Raiwai, Suva; Sb = Samabula, Suva; SP = Suva Point, SPC = Secretariat of the Pacific Community, Nabua; SS = Service St. area, Suva; SV = Sigatoka Valley; TG = Thurston Gardens, Suva; Tr = Tacirua, Suva Tv = Tamavua; Suva; USPl = USP Lower Campyus; USPu = USP Upper Campus; USPbg = USP Botanical Garden;, VS = Vesi St, Suva; Vv = Volivoli Village, Nadroga; Vw = Vatuwaqa, Suva: WR = Waimanu Rd, Suva.

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Aspidiaceae	*Tectaria latifolia (I)*	Black-stiped fern, otaloa	L	Lvu, Lm	SS	USPbg
Cycadaceae	*Cycas revoluta*	Japanese sago palm, king sago palm, Japanese cycad	M-H	Lvu, Fr	SS, CMB, ACS, CBS	RT, USPu
Cycadaceae	*Cycas rumphii (I)*	Queen sago, Rumphius' cycad, logologo	M-H	Lvu, Fr	SS, CMB, ACS, CBS	LV, Mk, RR, RS, RT, Tv, USPl, USPu
Acanthaceae	*Asystasia salicifolia*	Willow-leaved asystasia	L	Lvu	SS	Mk, MR, RS, Tv
Acanthaceae	*Blechum pyramidatum*	Browne's blechum	L	Lvu	SS	USPu
Acanthaceae	*Eranthemum pulchellum*	Blue eranthemum, blue sage	L_m	Lvu		Mk
Acanthaceae	*Hemigraphis alternata*	Metal leaf, cemetery plant	L-M	Lvu	SS	La, Lb, DS, Mk, MS, RS, SPC, Tv, USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Acanthaceae	*Odontonema tubiforme*	firespike	L	Lvu, Sy	SS	La, LB, Tv
Acanthaceae	*Pachystachys lutea*	yellow shrimp plant	L	Lvu, Fl,	SS	La
Acanthaceae	**Pachystachys spicata*	Cardinal's guard	L-M	Lvu, Fl,	SS, PHM	La
Acanthaceae	*Pseuderanthemum carruthersii var. reticulatum*	Yellow-veined false eranthemum, El Dorado	L	Lvu	SS, SWF	La
Acanthaceae	*Sanchezia speciosa*	Sanchezia, fire fingers	L-M	Lvu, Fl	PHM?	RT, Mk, USPu
Acanthaceae	*Thunbergia grandiflora*	Bengal clockvine, skyflower	L-M	Fl, Bd	?	Do, Fs, Tv
Amaranthaceae	*Amaranthus hybridus*	Indian spinach, amaranth spinach, chauraiya	L	Lvu	SS	RS
Anacardiaceae	*Dracontomelon vitiense (A)*	Dragon plum, tarawau	L	Lvu	SS	RS, USPu
Anacardiaceae	*Spondias dulcis (A)*	Polynesian vi-apple, wi	L	Lvu	SS	NF
Anacardiaceae	*Mangifera indica*	Mango, maqo	M	Lvu, Br, Fr	SS, CMB, BSM	BH, DW, NF, USPl, Tv, USPu.
Annonaceae	*Annona glabra*	Pond apple, uto ni bulumakau	L	Lvu, Fr	SS, CMB, BSM	Mk, Vw
Annonaceae	*Annona muricata*	Soursop, seremaia	L-H	Lvu, Fl, Fr	SS, CMB, CTM, BSM	GR, LV, Mk, NF, RS, Rw, Tv, USPl, USPu
Annonaceae	*Annona reticulata*	Bullock's heart, custard apple, uto ni bulumakau	M-H	Lvu	SS, CMB, BSM	La
Annonaceae	*Annona squamosa*	sweetsop	M-H	Fl, Fr	SS, CMB, BSM	GR, NF, RS

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Annonaceae	*Cananga odorata (A)*	ylangylang, makosoi	L-H	Fl. Lvu, Br, Tr	SS. BSM	La, LB, MR, USPu, RT, NF, NR
Annonaceae	*Polyalthia laddiana (E)*	mocelolo	L-M	Lvu	SS	DW, USPi
Annonaceae	*Polyalthia longifolia*	Ashok tree, sorrowful tree, ashoka	L-M	Lvu	SS	Mk, RS, SP, Tv, USPl, USPu
Apiaceae	*Eryngium foetidum*	Cilantro, Mexican coriander, long coriander, dhania	L-M	Lvu	SS	RT
Apocynaceae	*Alyxia stellata (I)*	Maile, vono	L	Lvu, St	SS	LBE, RT
Apocynaceae	*Ochrosia oppositifolia (I)*	Twin apple, vao	L	Fl	SS, CTM	USPu
Apocynaceae	*Plumeria obtusa*	White evergreen frangipani, bua ni vavalagi	L-M	Lvu	SS, CTM, PR, BSM	BH, USPl
Apocynaceae	*Plumeria rubra*	Red frangipani, common plumeria, bua ni vavalagi	L-M	Lvu	SS, PR, BSM	BH, GR
Araliaceae	*Polyscias filicifolia*	Golden hedge panax, golden prince, dalidali	L	LVu	SS	BH, LB, Mk, Tv, USPu
Araliaceae	*Polyscias guilfoylei*	Guilfoyle hedge panax, danidani	L	LVu	SS	RS
Araliaceae	*Polyscias scutellaria*	Bigleaf panax, danidani	L	LVu	SS	Do
Araliaceae	*Scheffera actinophylla*	Queensland umbrella tree, octopus tree	L	LVu	STS	NR

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Asteraceae	*Ageratum conyzoides*	Goatweed, botebote-koro	L	Lvu	SS, APH	USPu, RT
Asteraceae	*Crassocepha-lum crepidioides*	Redflower ragleaf, thickhead	L	Lvu	SS, APH, YA	Tv, USPu
Asteraceae	*Cyanthillium cinereum*	Little ironweed, kaukamea	L	Lvu	SS	USPu
Asteraceae	*Eleutheran-thera ruderalis*	ogiera	L	Lvu	SS	TG, USPu
Asteraceae	*Synedrella nodiflora*	nodeweed	L-M	Lvu	SS	LV, RT, RS, TV, USPu
Asteraceae	*Mikania micrantha*	Mile-a-min-ute, wabo-sucu	L	Lvu	SS	Mk, RT, TG
Basellaceae	*Basella alba*	Malabar spinach	L	Lvu, St	SS	LB
Bignoniaceae	*Mansoa hymenaea*	Garlic vine	L	Lvu	CTM	BH
Boraginaceae	*Cordia myxa*	Indian olive, Assyrian plum, lasora	L-M	Lvu	SS, BSS	USPu
Boraginaceae	*Cordia subcordata (I)*	Beach cor-dia, nawa-nawa	L	Lvu	SS, BSM	USPl
Caricaceae	*Carica papaya*	Papaya, pawpaw, weleti	L	Lvu	CMB, CBS, SWF	LV
Casuarinaceae	*Casuarina equisetifolia (I)*	Casuarina, she oak, ironwood, nokonoko	L	Lv, St	SS	USPu
Casuarinaceae	*Gymnostoma vitiense (E)*	Fiji casuari-na, velau	M	Lv, St	SS	Tv, USPl, USPu
Clusiaceae	*Calophyllum inophyllum (I)*	Alexandrian laurel, toma-no, beauty-leaf, dilo	L	Lvu	SS, CMB, BSM	USPl
Clusiaceae	*Garcinia sessilis (I)*	Heilala, heilala, bulu-wai, laubu	M	Lvu	SS	USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Chrysoblanaceae	*Atuna racemosa (I)*	makita	L	Lvu	SS	USPu
Combretaceae	*Quisqualis indica*	Rangoon creeper, sinu kakala	L	Lvu, St	SS	DW, LV
Combretaceae	*Terminalia catappa (I)*	Tropical almond, tavola, tivi	L	Lvy, Tb	BB	USPl
Convolvulaceae	*Ipomoea batatas*	Sweet potato, kumala	L	Lvu	SS	LV, LB
Convolvulaceae	*Ipomoea carnea* spp. *fistulosa*	bush morning - glory	L - M	Lvu	SS	WR
Convolvulaceae	*Merremia peltata (I)*	Merremia, wa damu	L-M	Lvu	SS	USPbg, USPu
Convolvulaceae	*Merremia tuberosa*	Woodrose, tuber rose	M-H	Lvu	SS	Do, USPbg, USPbg
Cucurbitaceae	*Citrullus lanatus*	Watermelon, meleni	L-M	Lvu	?	LV
Cucurbitaceae	*Coccinia grandis*	ivy gourd, kundru	L	Lvu	SS, CMB?	USPu
Cucurbitaceae	*Cucurbita moschata*	Pumpkin, wavukeni	L	Lvu	SS	LB, LV
Cucurbitaceae	*Cucumis sativus*	Cucumber, kukaba	L	Lvu	SS	LV
Cucurbitaceae	*Luffa acutangula*	Ridged gourd, angled loofa, toroi	L-M	Tb, Fl	SS	NR
Euphorbiaceae	*Acalphya hispida*	Chenille plant	H	Lvu, Fl, St	SS	Mk, SP, Tv, USPl, USPu,
Euhorbiaceae	*Acalypha wilkesiana (A)*	beefsteak plant, kalabuci dmu	L	Lvu	SS	McD, Mk
Euhorbiaceae	*Acalphya wilkesiana f. circinata*	Picotte acalypha	L	Lvu	SWF	NA, Vw
Euhorbiaceae	*Aleurites moluccana (A)*	Candlenut, lauci, sikeci	L	Lvu	CTM, MBD*	USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Euhorbiaceae	*Codiaeum variegatum (I or A?)*	Croton, saca-saca	L-M	Lvy, Tb	SS, CTM, BSM	LV, PTC, RT, Tv, USPl, USPu
Euhorbiaceae	*Endospermum macrophyllym (I)*	Whitewood, kauvula	L	Lyu	LTM	USPu
Euhorbiaceae	*Euphorbia cyathophora*	poinsettia	M	Lyu, Fl	SWF	Vw
Euhorbiaceae	*Euphorbia fidgiana (E)*	Fiji spurge, vasa damu	H	Lyu, St, Fl	SS	RT
Euhorbiaceae	*Excoecaria agallocha*	Blinding tree, sinu gaga	L	Lvu, St	SS	MS
Euphorbiaceae	*Macaranga segunda (I)*	Macaranga, davo, velutu	L	Lvu, St	SS, SWF	USPu
Euphorbiaceae	*Manihot esculenta*	Cassava, manioc, tavioka	L	Lvu	CBS, SWF	USPu
Euphorbiaceae	*Manihot carthaginensis var. glaziovii*	Tree cassava, Ceara rubber tree	L-M	Lvu	CBS, SWF	MK
Fabaceae	*Adenanthera pavonina*	Red-bead tree, lera	L	Lvu	SS	USPbg, USPu
Fabaceae	*Arachis hypogaea*	Peanut, groundnut	M-H	Lvu?	SS?	SV
Fabaceae	*Bauhinia variegata*	purple orchid tree	M-H	Lvu, Pt, St	SS, SWF, BSM	LB, USPu
Fabaceae	*Bauhinia monandra*	pink orchid tree, pink Bauhinia	M-H	Lvu, Pt, St	SS, BSM	LV, Tv
Fabaceae	*Calliandra surinamensis*	Pink powderpuff, Surinam calliandra	L-M	Lvu, St,	SS	NF
Fabaceae	*Calliandra calothyrsus*	calliandra, red calliandra	L	Lvu, St., Fl, FR	PHM, CTM	CS
Fabaceae	*Cassia fistula*	Golden shower tree, **vaivai ni vavalagi**	M-H	Lvu	SS. BSM	La, NF, QED, SP, USPu
Fabaceae	*Cassia javanica*	Pink-and-white shower tree	L	Lvu, Br	SS	USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Fabaceae	*Centrosoma pubescens*	Centro, butterfly pea	M	Lvu, St,	SS	SS
Fabaceae	*Cynometra insularis (I)*	Cibicibi, moivi	L-M	Lvu	SS	USPu
Fabaceae	*Derris trifoliata (I)*	Fish-poison vine, duva	L	Lvu	SS	MS
Fabaceae	*Gliricidia sepium*	Mother-of-cocoa, Mexican lilac, quickstick, bainicagi	L	Lvu	SS	USPu
Fabaceae	*Flemingia macrophylla*	Bigleaf flemingia, apa apa	M	Lvu, Fr	SS	Mk, USPu
Fabaceae	*Flemingia strobilifera*	Wild hops	M-H	Lvu, St	SS	USPbg, USPl
Fabaceae	*Inocarpus fagifer (I)*	Tahitian chestnut, ivi	L	Lvu, Fl	SS, NS	Tv, USPbg, USPl, USPu
Fabaceae	*Instsia bijuga (I)*	Pacifc teak, ipil-ipil, vesi	L-M	Lvu	SS	NF, USPl, USPu
Fabaceae	*Phaseolus vulgaris*	French bean, haricot bean	L-H	Lvu, Tb, Fl, Fr	SS	LB
Fabaceae	*Psophocarpus tertragonolobus*	Wing bean, four-cornered bean	M-H	Fl. Tb	SS	NL
Fabaceae	*Peltophorum pterocarpum*	Yellow poinciana, yellow flamboyant, copperpod	L	Lvu	SS	La, SP
Fabaceae	*Milletia pinnata (I)*	Beach walnut, pongam, vesiwai	L	Lvu, Tb	CTM	USPl
Fabaceae	*Pterocarpus indicus*	Burmese rosewood, Amboyna wood	L	Lvu	SS	USPu
Fabaceae	*Samanea saman*	**Raintree, monkeypod, vaivai moce**	L-H	Lvu, St	SS	DS, Mk, MS, RS, SP, USPl, USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Fabaceae	*Senna siamea*	Siamese cassia, kassod tree	L-M	Lvu, St	SS, SWF	SP, USPu
Fabaceae	*Tamarindus indicus*	Tamarind, imli, tamarini	M-H	Lvu, St, Fr	SS	SV
Fabaceae	*Vigna marina (I)*	beach pea, drautolu	L	Lvu	SS	RT
Fabaceae	*Vigna sesquipedalis*	Longbean, asparagus bean	L-M	Lvu, St, Fl	SS	DW, LB, RS, Tv
Gesneriaceae	*Chrysothemis pulchella*	dozakie	L	Lvu	SS	La, USPu
Goodeniaceae	*Scaevola taccada (I)*	Beach half-flower, Scaevola, vevedu	H	Lvu, St	SS	USPl. USPu
Lamiaceae	*Congea tomentosa*	woolly congea, shower orchid	M	Lvut	SS	BH
Lamiaceae	*Ocimum basilicum*	Sweet basil, tulsi	L-M	Lvu, Tb	PHM	RT
Lamiaceae	*Ocimum tenuiflorum*	Holy or sacred basil, tulsi	L-M	Lvu	SS, SWF	Tv
Lamiaceae	*Tectona grandis*	teak	L-H	Lvu, Lm	SS	La, Sb
Lauraceae	*Persea americana*	Avocado, pea	M-H	Lvu,	SS, CMB, CBS	Dw, Fs, KS, Mk, NF. RT, Tv, USPl, USPu, Vw
Lecythidaceae	*Couroupita guianensis*	Cannonball tree, dabi	M	Fl	SS, PHM	TG
Lecythidaceae	*Barringtonia asiatica (I)*	Fish-poison tree, **vutu rakaraka**	L	Lvu, Fl	SS, CMB, NS	QED, USPl, USPu
Lecythidaceae	*Barringtonia edulis(A)*	Cutnut, **vutukana, vutu vala**	L	Lvu,, Tb	SS, CMB	Fs, USPl, USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Fabaceae	*Senna siamea*	Siamese cassia, kassod tree	L-M	Lvu, St	SS, SWF	SP, USPu
Fabaceae	*Tamarindus indicus*	Tamarind, imli, tamarini	M-H	Lvu, St, Fr	SS	SV
Fabaceae	*Vigna marina (I)*	beach pea, drautolu	L	Lvu	SS	RT
Fabaceae	*Vigna sesquipedalis*	Longbean, asparagus bean	L-M	Lvu, St, Fl	SS	DW, LB, RS, Tv
Gesneriaceae	*Chrysothemis pulchella*	dozakie	L	Lvu	SS	La, USPu
Goodeniaceae	*Scaevola taccada (I)*	Beach half-flower, Scaevola, vevedu	H	Lvu, St	SS	USPl. USPu
Lamiaceae	*Congea tomentosa*	woolly congea, shower orchid	M	Lvut	SS	BH
Lamiaceae	*Ocimum basilicum*	Sweet basil, tulsi	L-M	Lvu, Tb	PHM	RT
Lamiaceae	*Ocimum tenuiflorum*	Holy or sacred basil, tulsi	L-M	Lvu	SS, SWF	Tv
Lamiaceae	*Tectona grandis*	teak	L-H	Lvu, Lm	SS	La, Sb
Lauraceae	*Persea americana*	Avocado, pea	M-H	Lvu,	SS, CMB, CBS	Dw, Fs, KS, Mk, NF. RT, Tv, USPl, USPu, Vw
Lecythidaceae	*Couroupita guianensis*	Cannonball tree, dabi	M	Fl	SS, PHM	TG
Lecythidaceae	*Barringtonia asiatica (I)*	Fish-poison tree, **vutu rakaraka**	L	Lvu, Fl	SS, CMB, NS	QED, USPl, USPu
Lecythidaceae	*Barringtonia edulis(A)*	Cutnut, **vutukana, vutu vala**	L	Lvu,, Tb	SS, CMB	Fs, USPl, USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Lythraceae	*Cuphea hyssopifolia*	Mexican heather	M-H	Lx, St, Fl	SS, SWF	RT, USPl, USPu
Lythraceae	*Lagerstroemia indica*	Crepe myrtle	L-M	Lvu	SS	Sb, USPu
Lythraceae	*Lagerstroemia speciosa*	Pride-of-India, Queen's crepe myrtle	L-M	Lvu	SS	Mk, USPu
Lythraceae	*Punica granatum*	Pomegranate,	L-M	Lvu	SS	USPl, USPu
Malvaceae	*Abelmoschus esculentus*	Orkra, bhindi	M-H	Lv, Fl, Fr	SS, PHM, APH	LV, RS, Rw
Malvaceae	*Abelmoschus manihot (A)*	Hybrid spinach, bele	L-M	Lvu, St	ASB, SS, APH	LV, Mk, NF, RT
Malvaceae	*Abutilon x hybrid*	mallow	L-M	Lvu, Tb	PHM	Vw
Malvaceae	*Gossypium barbadense*	Sea island cotton	L	Lvu, Tb	?	RR
Malvaceae	**Hibiscus mutabilis*	Changeable mallow	L-H	Lvu, Fl, St	PHM, CTM, SS	USPl, USPu
Malvaceae	**Hibiscus rosa-sinensis (A)*	small red hibiscus, senitoa	M	Bd, Fl, Ly	PHM	BH, DW, Gv, GR, KS, LV, Mk, NR, PR, PTC, RG, Tv, USP, SP
Malvaceae	**Hibiscus rosa-sinensis vars.*	Small light cream with red throat	L	Bd, Fl, Ly	PHM	BH
Malvaceae	**Hibiscus rosa-sinensis var.*	Small pink	L-M	Fl, Ly, St	PHM	BH, La, LB, PTC, RG, USPl, USPl
Malvaceae	**Hibiscus x rosa-sinensis*	Double red hibiscus	M-H	Fl, Ly, Ln	PHM	BH, Gv, Mk, RS
Malvaceae	**Hibiscus x hybrid*	Orange hybrid with light pink outer and deep red inner throat	L	Fl, Tb	PHM	SPC
Malvaceae	**Hibiscus x hybrid*	Pink hybrid?	M	Fl, Ly, St, Tb	PHM	BH, Na

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Malvaceae	**Hibiscus x hybrid*	Whitish-yellow hybrid	M	Fl, Ly, Tb	PHM	Vw
Malvaceae	**Hibiscus x hybrid*	Double yellow hibiscus	M	Fl, Ly, St, Tb	PHM	USPu, Vw
Malvaceae	**Hibiscus x hybrid*	Double white hibiscus	M	Fl, Ly, St, Tb	PHM	Vw
Malvaceae	**Hibiscus x hybrid*	Hybrid hibiscus	M	Fl, Ly	PHM	Gv
Malvaceae	**Hibiscus x storkii 2*	Hybrid hibiscus	M	Fl, Ly, St	PHM	PTC, USPl
Malvaceae	*Hibiscus sabdariffa*	Roselle, katha bhaji	L-M	Lvu, St	CTM, SS	LV, NF, NR, RT, Vw
Malvaceae	*Hibiscus tiliaceus (I)*	Beach hibiscus, vau	L	Fl, Lv	PHM	LB, RT, USPl, USPu
Malvaceae	*Hibiscus tiliaceus var. (A?)*	"vauleka" cultivar, vauleka	M-H	Fl, Lv, St, Tr	PHM	RT, Vw
Malvaceae	*Hibiscus tiliaceus var.*	Variegated wrinkled beach hibiscus cultivar	M-H	Lvu, St, Tr	PHM	Vw
Malvaceae	*Hibiscus schizopetalus var.*	Coral hibiscus, split-petalled hibiscus	L	Lvu	SS	BH
Malvaceae	*Malvaviscus penduliflorus*	Turk's cap, sleeping hibiscus	L-M	Fl, Lvu	SS	La, Mk, Do, St
Malvaceae	*Thespesia populnea (I)*	Thespian tree, portia tree, milo, mulomulo	L-M	Lvu,	SS, CTM, PHM	USPl
Malvaceae	*Urena lobata (A)*	Caesarweed, Pink hibiscus bur, qatima	L-M	Lvu, St	SS, SWF, NS	USPu
Meliaceae	*Dysoxylum richii (I)*	Stinkwood, tarawau kei rakakā, sasawira	L	Lvu	SS	USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Moraceae	*Artocarpus altilis A)*	Breadfruit, uto, kulu	L-H	Lvu		LV, Mk, NF, RT, Tv. USPu, Vv
Moraceae	*Artocarpus heterophyllus*	Jackfruit, katthar, uto ni Idia	M-H	Lvu, Lvt, St	SS	La, RT, LM, USPu
Moraceae	*Broussonetia papyrifera (A)*	Paper mulberry, masi	M	Lvu, Pt, St	SS,	La, LB, USPu
Moraceae	*Ficus barclayana (E)*	Barclay's fig, losilosi	M-H	Lvu, Lm	SS, CTM	DW, KS, RT, SPC, Tv, USPl, USPu
Moraceae	*Ficus pumila*	Climbing fig	M	Lvu	SS	DW, Mk, NR, Tv, USPu
Moraceae	*Ficus cf obliqua (I)*	Small-leaved fig, baka	M	Lvu, St	SS	TG
Moraceae	*Ficus religiosa*	Sacred banyan, bo tree	M	Lvu, St	SS	RR, Sb
Moraceae	*Ficus tinctoria (I)*	Dyer's fig, baka	L-M	Lvu, St	SS, NS	DW, USPu
Moraceae	*Ficus vitiensis (E)*	Fiji fig, lōlō	M-H	Lvu	SS	DW, RT
Moraceae	*Morus alba*	White mulberry, tut	L-M	Lvu	SS	Sb
Moringaceae	*Moringa oleifera*	horseradish tree, drumstick tree, , saijan	L	Lvu	SS	La
Myrtaceae	*Eugenia uniflora*	Surinam cherry	H	Lvu. St	SS	Na, USPu
Myrtaceae	*Psidium cattleyanum*	Strawberry guava	L-M	Lvu	SS, SWF	BH, LV, USPu
Myrtaceae	*Psidium guajava*	Guava, quwawa, am	M-H	Lvu	CMB, BSM, SS, SWF	BH, Gv, Mk, Na, NF, RT, SPC, Tv, USPl, Vw
Myrtaceae	*Syzygium corynocarpum (I)*	misimisi	M	Lvu, St, Fr	SS	LB, NF,,RT, RS, USPu
Myrtaceae	*Syzygium cumini*	Jambolan, jamun	L	Lvu	SS	USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Myrtaceae	*Syzygium jambos*	Rose apple, kavika ni vavalagi	L-M	Lvu	SS	USPu
Myrtaceae	*Syzygium malaccense (A)*	Malay apple, kavika	L	Lvu	SWF	USPu
Myrtaceae	*Syzygium neurocalyx (I)*	leba	H	Lvu, St	SS	LB
Myrtaceae	*Syzygium cf gracilipes (E)*	Native Syzygium sp., lutulutu, yasi?	L-M	Lvu	SS	DW
Oxalidaceae	*Averrhoa bilimbi*	Bilimbi, cucumber tree	L	Lvu, St	SS	USPu, TG
Oxalidaceae	*Averrhoa carambola*	Carambola, kamrakh, wi ni Jaina, wi ni Idia	L-M	Lvu, St, Fr,	SS	NF, LV, RS
Oxalidaceae	*Oxalis barrelieri*	Barrelier's woodsorrel	L	Lvu	SS	RT, USPu
Oxalidaceae	*Oxalis debilis*	Pink woodsorrel, lilac oxalis	L	Lvu	SS	RT, USPu
Passifloreaceae	*Passiflora suberosa*	Corkystem passionflower	L	Lvu	SS	USPu
Passifloreaceae	*Turnera ulmifolia*	Yellow alder	L-M	Lvu	SS	RT, USPu
Phyllanthaceae	*Bischofia javanica (I)*	Java cedar, Bishop's wood, koka	L	Lvu, St	SS, NS?	USPu
Phyllanthaceae	*Flueggea flexuosa*	poumuli	L	Lvu	SS	TG
Phyllanthaceae	*Phyllanthus tenellus*	Mascarene Islands leaf-flower	M-H	Lvu, St	SS	USPu
Piperaceae	*Piper aduncum*	spiked pepper bush, matico, yaqona ni Onolulu	L-M	Lvu	SS, CTM	CS, RT, Tr, USPl, USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Piperaceae	*Piper auritum*	hoja santa, sacred leaf, Mexican pepperleaf, yaqona ni Toga	L-M	Lvu	SS	Tr
Piperaceae	*Piper betle*	Betel pepper, paan	L-M	Lvu	SS	NR, RT
Polygonaceae	*Antigonon leptopus*	Mexican creeper, coral vine, beebush	L	Lvu	SS	Fs
Rosaceae	*Rosa x damascena*	Damask rose	L	Lvu, St	SS	Sb, Tv, Vw
Rubiaceae	*Coffea cf arabica*	Arabian coffee	M	Lvu	NS, SS, CMB, MBD*	DW, NF, USPu
Rubiaceae	*Gardenia jasminoides*	Common gardenia, cape jasmine, jiale ni vavalagi	L-M	Fl, Fr, Lv, St	SS, CTM, PHM, BSM	BH, La, LB, Mk, RT, USPl, USPu
Rubiaceae	*Gardenia hutchinsonii (E)*	Hutchinson's gardenia	M-H	Fl, Fr, Ly	SS?	DW
Rubiaceae	**Gardenia taitensis (I)*	Tahitian gardenia. Jiale ni Taiti	M-H	Fl, Fr, Ly	SS, PHM, CTM, BSM, MBD*	Dw, RT, USPu
Rubiaceae	**Ixora casei*	Giant red ixora, sinu ni vavalagi	L	Lv. Fl	SS. PHM, CBS, BSM	RT, USPl, Tv, Vw
Rubiaceae	**Ixora chinensis*	Chinese ixora, sinu ni vavalagi	L-M	Lv, Fl	PHB, SS, MBD*	LB, Gv, MK, RT, USPl, USPl
Rubiaceae	**Ixora coccinea*	Red ixora, sinu ni vavalagi	L-H	Lv. Fl, Bd	SS, PHM, NS	La, LB, Mk, PTC, RS, RT, SPC, Tv, USPl, USPu
Rubiaceae	*Ixora finlaysoniana*	white ixora, sinu ni vavalagi	L	Lv	SS	La, Mk, RT

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Rubiaceae	**Ixora javanica*	orange ixora	L-M	Lv, Fl, Tb	PHB, SWF, CBS	RR
Rubiaceae	**Ixora lutea*	yellow ixora	L	Lv, Fl	PHB, SS	La, Mk, USPl, USPu, Vw
Rubiaceae	**Ixora siamea*	pink ixora	L-M	Lv, Fl, Bd	PHM, SS, SWF, BSM	La, Mk, SPC, USPl,
Rubiaceae	*Morinda citrifolia (I or A)*	Indian mulberry, noni, kura	L-H	Lv, Fr, Fl	PHM, CTM, BSM	Mk, RT, Rw, Vw, USPu
Rubiaceae	*Mussaenda erythrophylla x philippica*	pink mussaenda	L-H	Lvu, St	CTM, NS, SWF	Mk, RT, USPu
Rubiaceae	*Mussaenda philippica*	white mussaenda	L-M	Lvu, St, Sc	CTM	Mk, RT, Tv, USPu
Rubiaceae	*Pentas lanceolata*	Egyptian starcluster, pentas	L-M	Lvu	SS	Mk, RT, Tv, Vw
Rutaceae	*X Citrofortunella microcarpus*	Calamondin orange, “kumquat”	L-M	Lvu, St,	SS, BSM	LB, La, NF, RT
Rutaceae	*Citrus aurantiifolia*	Lime, mili laini	M	Fl, Ly, St	SS	DW, LB, RT, Vw
Rutaceae	*Citrus aurantium*	sour orange, mili kula	L-M	Lv, Fl	SS, BSM	RT, USP, Vw
Rutaceae	*Citrus x jambhiri (C. reticulate x C. medica*	Rough lemon, moli karokaro	M	Lvu, St	SS	BH, DW, La, LB, VU, RT, USPl, USPu, Vw
Rutaceae	*Citrus maxima (A)*	Pomelo, mili kana	M-H	Lvu	SS, NS?, BSM	Sb, Vw
Rutaceae	*Citrus x limon*	Hybrid lemon	L	Lv	SS	La, LB, RT, USP, BH
Rutaceae	*Citrus reticulata*	Mandarin orange	M	Lv, Fl, St	SS, BSM	DW, LB, LV, RS, RT, Tv, USPlu
Rutaceae	*Citrus x sinensis*	Sweet orange, moli Taiti	L-M	Lvu	SS, BSM	La, LB, LV. RT, USPu, Vw

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Rutaceae	*Euodia hortensis (A?)*	Island musk, uci	M-H	Lvu	SS	La, LB, BH , DS, DW, KR, Mk, MR, RS, RT, SPC, USPlu,
Rutaceae	*Micromelum minutum (I)*	Lime berry, sasaqilu	L	Lv	SS	LB
Rutaceae	*Murraya koenigii*	curry leaf, curry tree, Indian bay-leaf, tejpatti	L	Lvu	SS	RT
Rutaceae	*Murraya paniculata*	Orange jessamine	L	Lvu	SS	La
Santalaceae	*Santalum yasi (I)*	Fiji sandal-wood, yasi	L-M	Lvu, St, Tr	SS	LB, USPu
Sapindaceae	*Acer cf palmatum*	Palmate maple, Japanese maple	M	Lv, St	SS	USPu
Sapindaceae	*Filicium decipiens*	Fern tree, fern leaf	L	Lv, St	SS	LV, NF, RT
Sapindaceae	*Pometia pinnata (A)*	Island lychee, oceanic lychee	L	Lvu	SS	USPu
Sapotaceae	*Manilkara zapota*	Sapodilla,	M-H	Lvu	SS	RT
Solanaceae	*Brugmansia x candida*	Angel's trumpet	L	Lvu	SS	VS
Solanaceae	*Brunfelsia paucifolia*	Yesterday-today- -and-tomorrow	L	Lvu, Pt, Fl	SS, CTM	DS, LB, RS, Tv, USPl, USPu
Rubiaceae	*Ixora finlaysoniana*	white ixora, sinu ni vavalagi	L	Lv	SS	La, Mk, RT
Solanaceae	*Capsicum annuum var. annuum*	Sweet capsicum, bell peppers	M	Lvu	SS?	LV, RS, TV
Solanaceae	*Capsicum annuum vars.*	Chili peppers, rokete	M	Lvu	SS, SWF	DW, Mk, RS, RT, Tv
Solanaceae	*Capsicum annuum vars.*	Ornamental black chili pepper	M	Lvu	SS	Vw

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Solanaceae	*Capsicum frutescens.*	Tabasco, bird chili peppers, rokete	L	Lvu	SS, SWF	DS, LV, RS, RT
Solanaceae	*Cestrum nocturnum*	Night-blooming jasmine, night jessamine, caucau ni bogi	L	Lvu, St, Sc	SS. APH	RT, USPu
Solanaceae	*Solanum americanum (A?)*	Black nightshade, malasou	L	Lvu, St	SS, APH	La, Mk
Solanaceae	*Solanum lycopersicon*	Tomato, tomato	L-M	Lvu, St	SS?	LB, RS
Solanaceae	*Solanum melongena*	Eggplant, baigani	L-M	Lvu, St	SS	LV, NF, RS
Solanaceae	*Solanum torvum*	Prickly solanum, devil's fig, soni	L-M	Lvu.	SS	Mk, RS, USPu
Thymelaeaceae	*Phaleria disperma (I)*	Sinu, sinu ni baravi, mataivi	M	Lvu, Fl, Fr	CTM	DW
Urticaceae	*Boehmeria cf macrophylla*	False nettle	L	Lvu	SS	La
Urticaceae	*Pilea nummularifolia*	Creeping Charlie	L	Lvu	SS	USPu
Verbenaceae	*Clerodendrum chinense*	Chinese glory bower	L	Lvu	SS	DS, Tv
Verbenaceae	*Clerodendrum paniculatum*	Pagoda flower	L	Lvu	SS	RT
Verbenaceae	*Clerodendrum quadriloculare*	Philippine glory-bower, starburst	L-M	Lvu, Fl, Tb	CTB, SS, UKS	NR, USPl, USPu
Verbenaceae	*Clerodendrum wallichii*	Wallich's clerodendrum	H	St, Lvu	SS	La, USPl
Verbenaceae	*Duranta erecta*	Golden dewdrops	L	Lvu	SS	Mk, USPl
Verbenaceae	*Vitex trifolia (I)*	Blue vitex, dralakaka	L-M	Lvu, St	SS	MS, USPu
Vitaceae	*Vitis sp.*	Grapevine, grape	L	Lvu	SS, rust?	Vw
MONOCOTYLEDONS						
Agavaceae	*Cordyline fruticosa (A)*	Ti plant	M-H	Lvu, Ls, Sp	SS. CMB, PS, NS, BSS, BSM	RT, Na, Tv, Vw, USPl, USPu

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Araceae	*Aglaonema commutatum*	Chinese evergreen	L-M	Lvu, Sc	SS	USPu
Araceae	*Alocasia cucullata*	Chinese taro	L	Lvu	SS	LV
Araceae	*Alocasia macrorrhizos (A)*	Giant taro, via mila	L	Lvu	SS	LV
Araceae	*Anthurium andreanum*	Anthurium, tail flower, flamingo flower	L	Lvu	SS, CMB	La, LB, SPC, Vw
Araceae	*Colocasia esculenta (A)*	Taro, dalo	L-M	Lvu, Pt	SS, APH	LV, NF, MS, UP-Pbg
Araceae	*Epipremnum aureum*	Golden pothos, devils ivy, taro vine	L	Lvu	SS	RT
Araceae	*Epipremnum pinnatum (I)*	Centipede tonga vine, yalu	L	Lvu, Pt	SS	DW
Araceae	*Monstera deliciosa*	Swiss cheese plant, monstera,	L	Lvu, Sp	SS	RT
Araceae	*Philodendron cf. scandens*	Heart-leaf philodendron	L	Lvu	SS, CMB, NS	La, LBMk, USPu
Araceae	*Philodendron cultivar*	Philodendron cultivar	L-M	Lvu	SS, CMB	La, LBMk, USPu
Araceae	*Spathophyllum wallisii 'Clevelandii'*	White sails, peace flower	L	Lvu	SS, NS	La, LB, USPbg
Araceae	*Syngodium podophyllum*	Arrowhead vine	L-M	Lvu	SS	La, LB, USPbg
Araceae	*Xanthosoma brasiliense*	Belembe, tanier spinach, Tahitian spinach	H	Lvu	SS	RT
Araceae	*Xanthosoma sagittifolium*	Tannia, yautia, American taro, arrowhead elephant ear	L	Lvu	SS, APH	LV, RT

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Arecaceae	*Acrocomia aculeata*	Macaw palm, grugru palm, Macauba palm	L	Lvu, Fr	SS, CMB	USPu
Arecaceae	*Areca catechu*	Belelnut palm, supari	L	Lvu, fs, Fr	SS	NR, USPu
Arecaceae	*Areca vestiaria*	Orange crownshaft palm	L	Lvu	SS	USPbg
Arecaceae	*Bismarckia nobilis*	Bismarck palm	L	Lvu	CBM, SS	USPbg, USPl
Arecaceae	*Bactris gasipaes*	peach palm, pejibaye	L	Lvu, Fs	CBM, SS	USPbg, USPl
Arecaceae	*Caryota sp.*	Fishtail palm	L-M	Lvu, Mk, St, Pt	CMB, SS, BSM	USPl
Arecaceae	*Chrisalidocarpus lutescens*	Golden can palm	M-H	Lvu, St, Sp	CMB, SS, BSM	BH, Mk, SP, RS, RT, Tv, USPl, USPu
Arecaceae	*Cocos nucifera (I or A)*	Coconut palm, niu	L-M	Lvu, Sp, Fl, Fs, Fr		BH, Mk, SP, USPu
Arecaceae	*Cyrtostachys renda*	Red palm, sealing wax palm, lipstick palm	Lvu	Lvu, Sp	SS	BH, DW, SP, USPu
Arecaceae	*Licuala grandis*	ruffled fan palm	L	Lvu, Fl, Fs	SS, CMB, BSM	Fs, KS, TG, USPu
Arecaceae	*Livistona chinensis*	Chinese fan palm, shower palm	L-H	Lvu, St, Fs	SS, CMB, BSM	Mk, Na, Tv, USPbg, USPu
Arecaceae	*Metroxylon vitiense*	Fiji sago plam, soga	L	Lv, Ls	CMB	USPu
Arecaceae	*Pelagodoxa henyana*	Marquesas palm	l	Lvu, Lm, Fs	CMB?	LE
Arecaceae	*Phoenix roebelenii*	Dwarf date palm	M	Lvu, Lm	CMB	Vw
Arecaceae	*Pinanga coronata*	Ivory cane palm	L	Lvu	SS	USPbg

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Arecaceae	*Acrocomia aculeata*	Macaw palm, grugru palm, Macauba palm	L	Lvu, Fr	SS, CMB	USPu
Arecaceae	*Areca catechu*	Belelnut palm, supari	L	Lvu, fs, Fr	SS	NR, USPu
Arecaceae	*Areca vestiaria*	Orange crownshaft palm	L	Lvu	SS	USPbg
Arecaceae	*Bismarckia nobilis*	Bismarck palm	L	Lvu	CBM, SS	USPbg, USPl
Arecaceae	*Bactris gasipaes*	peach palm, pejibaye	L	Lvu, Fs	CBM, SS	USPbg, USPl
Arecaceae	*Caryota sp.*	Fishtail palm	L-M	Lvu, Mk, St, Pt	CMB, SS, BSM	USPl
Arecaceae	*Chrisalidocarpus lutescens*	Golden can palm	M-H	Lvu, St, Sp	CMB, SS, BSM	BH, Mk, SP, RS, RT, Tv, USPl, USPu
Arecaceae	*Cocos nucifera (I or A)*	Coconut palm, niu	L-M	Lvu, Sp, Fl, Fs, Fr		BH, Mk, SP, USPu
Arecaceae	*Cyrtostachys renda*	Red palm, sealing wax palm, lipstick palm	Lvu	Lvu, Sp	SS	BH, DW, SP, USPu
Arecaceae	*Licuala grandis*	ruffled fan palm	L	Lvu, Fl, Fs	SS, CMB, BSM	Fs, KS, TG, USPu
Arecaceae	*Livistona chinensis*	Chinese fan palm, shower palm	L-H	Lvu, St, Fs	SS, CMB, BSM	Mk, Na, Tv, USPbg, USPu
Arecaceae	*Metroxylon vitiense*	Fiji sago plam, soga	L	Lv, Ls	CMB	USPu
Arecaceae	*Pelagodoxa henyana*	Marquesas palm	l	Lvu, Lm, Fs	CMB?	LE
Arecaceae	*Phoenix roebelenii*	Dwarf date palm	M	Lvu, Lm	CMB	Vw
Arecaceae	*Pinanga coronata*	Ivory cane palm	L	Lvu	SS	USPbg

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Arecaceae	*Pritchardia pacifica (I or A)*	Fiji fan palm, Pacific fan palm, viu, niu masei, niu sawa	M-H	Lvu, St, FL, Fr, Fs, Sp	SS, CMB	BH, Mk, RS, SP, USPu, Tv
Arecaceae	*Ptychosperma macarthurii*	Macarthur palm	L-M	Lvu, Fl, Fs	SS, CMB, BSM	DS, Mk, LV, Tv, USPu
Arecaceae	*Rhaphis excelsa*	Lady palm	L	Lvu, St	SS	Mk, MR, Sb, Tv
Arecaceae	*Rhaphis subtilis*	Dwarf lady palm	L	Lvu, St	SS	Mk, US-Pbg
Arecaceae	*Sabal minor*	bush palmetto	M-H	Lvu, Lvt, Fs, Fr	SS	USPl
Arecaceae	*Sabal palmetto*	Palmetto, thatch palm	L	Lvu, Sp	SS, CMB	USPu
Arecaceae	*Veitchia merrillii*	Manila palm, Christmas palm	L	Lvu, Fs	CMB	USPu
Asparagaceae	*Dracaena fragrans*	Fragrant dracaena, cornstalk dracaena, dragon flower, vasili ni vavalagi	L	Lvu		LV, USPu
Cannaceae	*Canna indica*	Indian shot	L	Lvu	SS, PR	Do, La, USPbg
Commelinaceae	*Commelina diffusa*	Dayflower, cobula	L	Lvu	SS	USPu
Commelinaceae	*Tradescantia zebrina*	Wandering Jew, inch flower	L	Lvu	SS	USPu
Costaceae	*Cheilocostus speciosus*	Crepe ginger	L-M	Lvu, St, Fl, Fm	CMB	DS,La, LB, Mk, Tv, USPu
Costaceae	*Costus woodsonii*	Scarlet spiral flag	M	Lvu		La, DS
Dioscoreaceae	*Dioscorea nummularia (A)*	Pacific yam, tivoli	L	Lvu		LV

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Heliconiaceae	*Heliconia bihai*	Lobster claw, firebird heliconia	L	Lyu,		La, USPu
Heliconiaceae	*Heliconia caribaea*	Caribbean heliconia	L-M	Lyu, Sy, Lm	SS	RT
Heliconiaceae	*Heliconia caribaea x bihai cv 'Jaquinii'*	Jacquin heliconia	L-M	Lyu, Sy, Lm	SS	RT
Heliconiaceae	*Heliconia collinsiana*	Hanging red heliconia	L	Lyu, Lm	CMB, SS	La
Heliconiaceae	*Heliconia hirsuta*	Heliconia cv. Roberto Burle-Marx	L-M	Lyu, Lm	SS	USPu
Heliconiaceae	*Heliconia lathispatha*	Golden lobster's claw heliconia	M	Lv, Lm, Fl	CMB, CBS	La, Vw
Heliconiaceae	*Heliconia psittacorum*	parakeet or golden troch heliconia	M-H	Lv, Lm, St, Na	CMB, SS	Mk, Na, Rt,USPu
Heliconiaceae	*Heliconia psitticorum x lathispatha*	"golden torch"	L-M	Lv, Lm	CMB	Vw
Heliconiaceae	*Heliconia rostrata*	Hanging Lobster-claw heliconia	M	Lv, St	CMB, SS	La, LB, Na, RT, USPu
Heliconiaceae	*Heliconia stricta*	Lobster-claw heliconia	M	Lv, St	CMB, SS	Do, USPu, Vw
Iridaceae	*Trimezia martinicensis*	Walking iris	L	Lvu, St	SS	LV, USPl
Liliaceae	*Gloriosa superba*	Climbing lily, Gloriosa lily	L	Lvu	SS	RT
Marantaceae	*Calathea crotalifera*	Rattlesnake plant, bati ni tadruku	M-H	Lvu, St	CMB, SS	La, LB, USPu, Vw
Marantaceae	*Calathea ornata*	Pinstripe calathea	L	Lvu, Lm	CMB SS	La
Marantaceae	*Calathea zebrina*	Zebra plant, zebra calathea	L	Lvu	SS	NR

Family	Species	Common Names	Inf Lev	Pts Inf	IAS	Locations
Musaceae	*Musa* AAA Group	Cavendish banana, jaina	L	Lv, Ls, Ps		Lb, Mk
Musaceae	*Musa* AB Group	Lady's finger banana, liga ni marama	L-M	Lv, Ls, Ps	SS	RT
Musaceae	*Musa* AAB Group (A)	Pacific plantain, vudi	L	Lv, Ls, Ps	CMB?	RT
Musaceae	*Musa velutina*	Pink banana, hairy banana	L	Lv, Lm	CMB	La
Pandanaceae	*Pandanus joskei (E)*	Joske's pandanus, kukuwalu	L-M	Lv, La, Fr, Fs	CMB?	Mk, USPl
Pandanaceae	*Pandanus tectorius (I)*	Pandanus, screwpine, vadra	L-M	Lv, La, Fr, Fs	CMB, PMB, MBD*	Mk, USPl
Poaceae	*Bambusa vulgaris*	Common bamboo, bitu ni vavalagi	St,	St, Ls	CTM	RT, USPu
Poaceae	*Saccharum officinarum (A)*	Sugarcane, dovu, ganna	L-M	Lv,, Ls	CTM, SBS	USPu
Zingiberaceae	*Alpinia purpurata*	red ginger, cevuga damu	L-H	Lvu, Fl, St	SS, CMB, PHM?	DW, La, Mk, RT, SPC, Tv, USPu
Zingiberaceae	*Alpinia vittata*	Variegated ginger	*L-H*	Lvu, Fl	SS, APH	DW, Mk, NR, RT, SPC, Tv
Zingiberaceae	*Hedychium coccineum*	pink ginger	A-L	Lvu, Fl	CMB	Mk
Zingiberaceae	*Hedychium coronarium*	white ginger	A-L	Lvu, Fl	SS	La, RT, USPu
Zingiberaceae	*Zingiber officinale*	Common ginger	L	Lvu	SS	LV
Zingiberaceae	*Zingiber zerumbet (A)*	Bitter ginger, shampoo ginger, cagolaya	L	Lvu	SS	USPl

Appendix III

Common native and introduced mainly woody plant species that are un-affected or almost never affected by the WFA-mealybug and sap-sucking insect bio-invasion in Fiji based on field studies by R. Thaman from May—September 2017 (Notes: 1) * = common species showing very limited incidental infestation in only one or few locations, but uninfested in almost all sites; 2) main sources (for origen/comments): Quisumbing 1951; Whistler 1980, 1994, 2000; Hammond 1995; Guevara et al. 1996; Argueta 1994; Thaman 1999, 2011; Quattrocchi, U. 2012; Thaman et al. 2012; Thaman et al. 2013; Brown 2013; Gilman and Watson 2013; Moghadamtousi et al. 2013; Dinesh et al. 2014).

Family	Species	Common Name	Origen/comments
Acanthaceae	*Thunbergia erecta*	bush thunbergia	Trop. W. Africa
Apocynaceae	*Allamanda cathartica*	yellow allamanda	South America; highly poisonous sap
Apocynaceae	*Catharanthus roseus*	Madagascar periwinkle	Madagascar; poisonous sap; medicinally plant
Apocynaceae	*Cerbera manghas*	sea mango, vasa, rewa	Indo-Pacific; coastal plant; poisonous sap; medicinal plant; used as fish poison
Apocynaceae	*Nerium oleander*	oleander	Mediterranean; highly poisonous sap
Apocynaceae	*Tabernaemontana divaricata*	crape jasmine, false gardenia, chameli	N. India; milky sap; medicinal plant
Apocynaceae	*Cascabela thevetia*	Yellow oleander, be-still tree	Mexico and C. America; very poisonous sap
Araliaceae	**Polyscias filicifolia*	fernleaf panax, golden prince. dalidali	S.E Asia; hedge plant
Araliaceae	*Polyscias fruticosa*	Ming aralia, parsley panax, danidani	Malaysia; hedge plant
Araliaceae	**Polyscias guilfoylei*	Guilfoyle hedge panax, danidani	Melanesia; hedge plant
Araliaceae	**Polyscias scuttelaria*	bigleaf panax, danidani	Solomon Is. and Vanuatu; hedge plant
Araliaceae	*Schefflera actinophylla*	Queensland umbrella tree, octopus tree	Indonesia to PNG and Australia; invasive species
Araliaceae	*Schefflera arboricola*	dwarf Schefflera	Taiwan; poisonous sap
Asclepiadaceae	*Calotropis gigantea*	crownflower, giant milkweed	India and Southeast Asia; poisonous sap

Family	Species	Common Name	Origen/comments
Asteraceae	Sphagneticola trliobata	wedelia, trailing daisy	Trop. America; toxic to goats; medicinal plant in trop. America
Euphorbiaceae	*Aleurites moluccana	candlenut, lauci, sikeci	S. Asia; medicinal plant; contains toxic saponins
Euphorbiaceae	Breynia disticha	leaf-flower of the Pacific Islands	Melanesia; important hedge plant
Euphorbiaceae	*Bischofia javanica	Java cedar, koka	Malesia to Melanesia; important Pacific medicinal plant; strong tannins; NFT; protected in fallow vegetation
Euphorbiaceae	Euphorbia cotinifolia	red spurge, heiba mala	W. Mexico; poisonous milky sap; medicinal plant; fish poison
Euphorbiaceae	*Excoecaria agallocha*	blinding tree, sinu gaga	Indo-Pacific; coastal mangrove plant; poisonous sap; medicinal plant
Euphorbiaceae	Glochidion concolor	buttonwood, molau	Vanuatu to Tonga; important Pacific medicinal plant
Euphorbiaceae	Jatropha curcas	physic nut, wiriwiri ni vavalagi, banidakai	Mexico, W. Indies to Brazil; poisonous sap and fruit; medicinal plant
Euphorbiaceae	Jatropha integerrima	Rose-coloured jatropha	Cuba; poisonous sap
Euphorbiaceae	Pedilanthes tithymaloides	Redbird cactus, slipper flower, Zigzag plant	W. Indies; poisonous sap
Fabaceae	Delonix regia	Poinciana, flame tree, seikoula	Madagascar; no known pests in Florida
Fabaceae	Erythrina variegata	Coral tree, dadap, drala	Indo-Pacific; medicinal plant

Family	Species	Common Name	Origen/comments
Fabaceae	**Gliricidia sepium*	Mother-of-cocoa, Mexican lilac, quickstick, bainicagi	Central and N. South America; NFT; seeds poisonous to rats
Fabaceae	*Leucaena leucocephala*	Leucaena, false tamarind; highly invasive species, vaivai ni vavalagi	South and East Asia and Western Pacific; NFT; contains toxic glucosides
Fabaceae	**Milletia pinnata*	Pongam tree, beach walnut, vesiwai	South and East Asia and W. Pacific; coastal plant; important Pacific medicinal plant
Hernandiaceae	*Hernandia nymphaeifolia*	Chinese lantern tree, evuevu	Indo-Pacific; coastal plants; medicinal plant
Lamiaceae	*Plectranthus amboinicus*	Indian borage	Southern and E. Africa; very aromatic; important medicinal plant
Lamiaceae	*Plectranthus scutellarioides*	Coleus, variegated coleus, lata	India to China; used to protect gardens from insects and evil spirits,
Meliaceae	*Azedarachta indica*	Neem tree, nim, neem	India to E. Indies; used as an organic insecticide; medicinal plant
Meliaceae	*Melia azedarach*	Indian lilac, China berry, Persian lilic	Trop. Asia; insect repellent; medicinal plant
Meliaceae	*Swietenia macrophylla*	Bigleaf mahogany. mahakoni	C. and S. America; medicinal use; strong tannins
Meliaceae	*Xylocarpus granatum*	cannonball tree, dabī	Indo-Pacific; coastal tree; important Pacific medicinal plant

Family	Species	Common Name	Origen/comments
Moraceae	*Ficus benjamina*	Weeping banyan, Benjamin tree, Benjamin fig, baka ni Idia	Trop. Asia; medicinal plant; strong tannins
Moraceae	*Ficus elastica*	Indian rubber tree, rubber plant	India; thick milky sap; thick rubbery leaves; medicinal plant
Myrtaceae	*Pimenta racemosa*	Bay rum tree, sinamoni	Caribbean; aromatic oil; medicinal plant
Myrtaceae	**Syzygium malaccense*	Malay apple, mountain apple, kavika	S.E. Asia, New Guinea and Australia; important medicinal plant
Nyctaginaceae	*Bougainvillea spp.*	Bougainvillea, pukanivili	S. America, possibly Brazil; used medicinally in Trop. America
Phytolaccaceae	*Rivina humilis*	Pigeonberry, Bloodberry, rougelant	Trop and subtropical America; invasive; medicinal plant
Piperaceae	*Piper methysticum*	Kava, yaqona	W. Melanesia, possibly Vanuatu; important medicinal and psychotoxic beverage plant
Rhizophoraceae	*Bruguiera gymnorhiza*	Red mangrove, brown mangrove, dogo	Indo-Pacific; mangrove species; important medicinal plant and source of tannin
Rhizophoraceae	*Rhozophora mangle*	Red mangrove, tiri, tiri wai	West Africa, New World to Fiji and New Caledonia; mangrove species; important medicinal plant
Rhizophoraceae	*Rhozophora stylosa*	Mucronate or spotted mangrove, tiri, tiri solo,	Malesia and Taiwan to Fiji, Tonga and Tuvalu; Caledonia; mangrove species; important medicinal plant

Family	Species	Common Name	Origen/comments
Solanaceae	**Cestrum nocturnum*	Night cestrum, night-blooming cestrum, cacucau ni bogi	Trop. America; milky sap; fruit poisonous to humans
Verbenacee	*Citharexylum spinosum*	Fiddlwqood, masese	W. Indies and N. S. America; medicinal use; invasive in Fiji
Verbenacee	*Clerodendrum inerme*	Beach privet, verevere	Indo-Pacific; coastal shrub; important Pacific medicinal plant
Verbenacee	**Clerodendrum thomsonae*	Bleeding heart	Trop. W. Africa; medicinal plant
Verbenacee	**Duranta erecta*	Golden dewdrops	Mexico, Caribbean to S. America; hedge plant; fruits poisonous; thorny invasive
Verbenaceae	*Lantana camara*	Lantana, lanitana	W. Indies; fruits and leaves poisonous; medicinal plant; highly invasive
Verbenaceae	*Premna serratifolia*	Beach elderberry, yaro	Indo-Pacific; coastal; important medicinal plant
Araceae	*Dieffenbachia seguine*	Dumb cane;	Brazil; poisonous irritating sap
Asparagaceae	*Dracaena angustafolia*	Striped dragon plant	Australia and Melanesia
Asparagaceae	*Dracaena fragrans*	Cornstalk dracaena, Fragrant dracaena, vasili ni vavalagi	W. Africa
Asparagaceae	*Dracaena marginata*	Madagascar dragon tree	Madagascar
Poaceae	*Bambusa multiplex*	Hedge bamboo, bitu sanisani?	S. Asia; hedge plant
Poaceae	*Bambusa vulgaris*	Common bamboo, bitu ni viti	Indochina and S. China
Strelitziaceae	*Ravenala madagascariensis*	Traveller's palm	Madagascar

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The University of the South Pacific

ISBN 978-982-01-0975-9