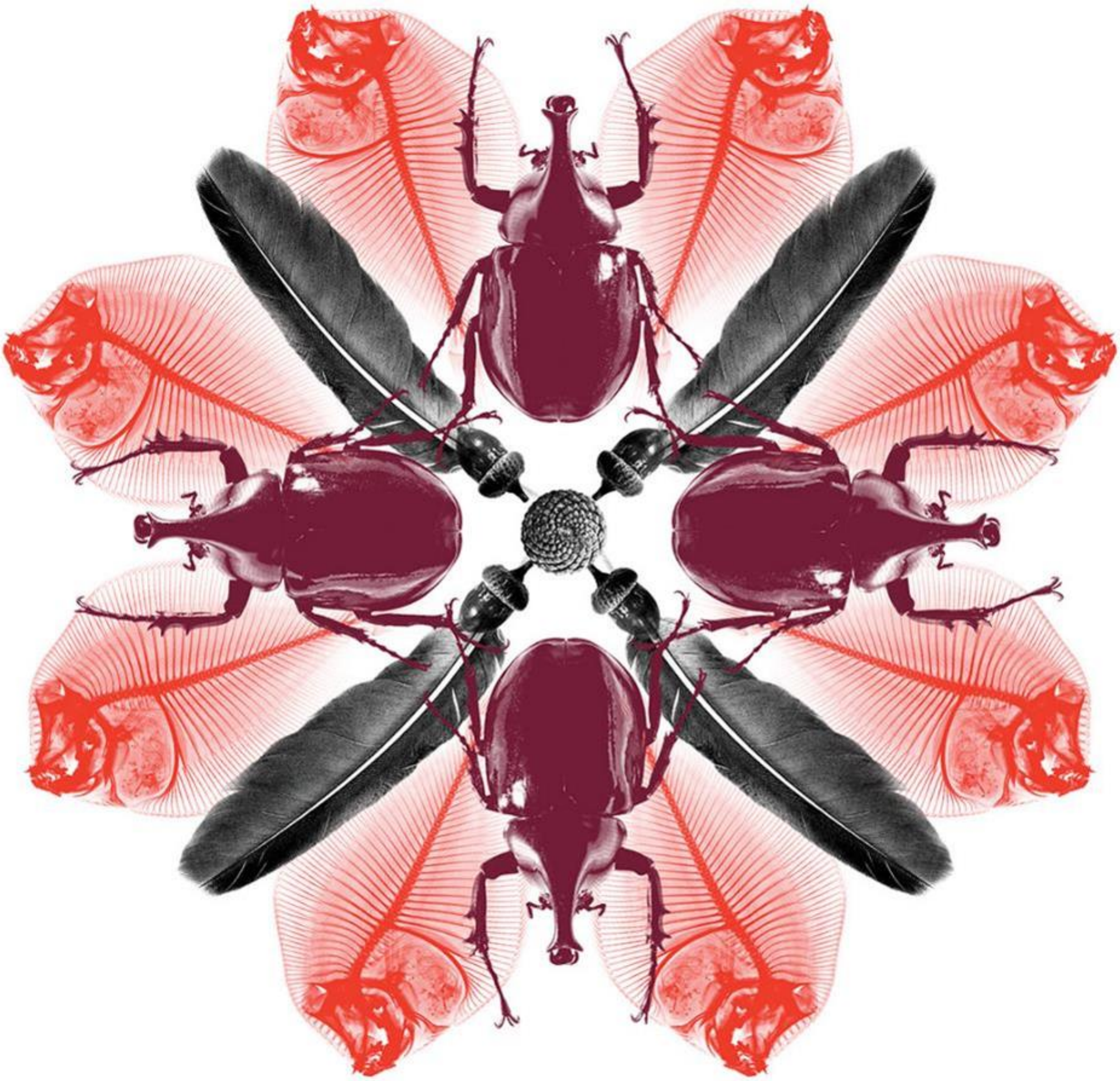
Australian Government
Department of Agriculture

Final report for the review of biosecurity import requirements for fresh breadfruit from Fiji, Samoa and Tonga

September 2019



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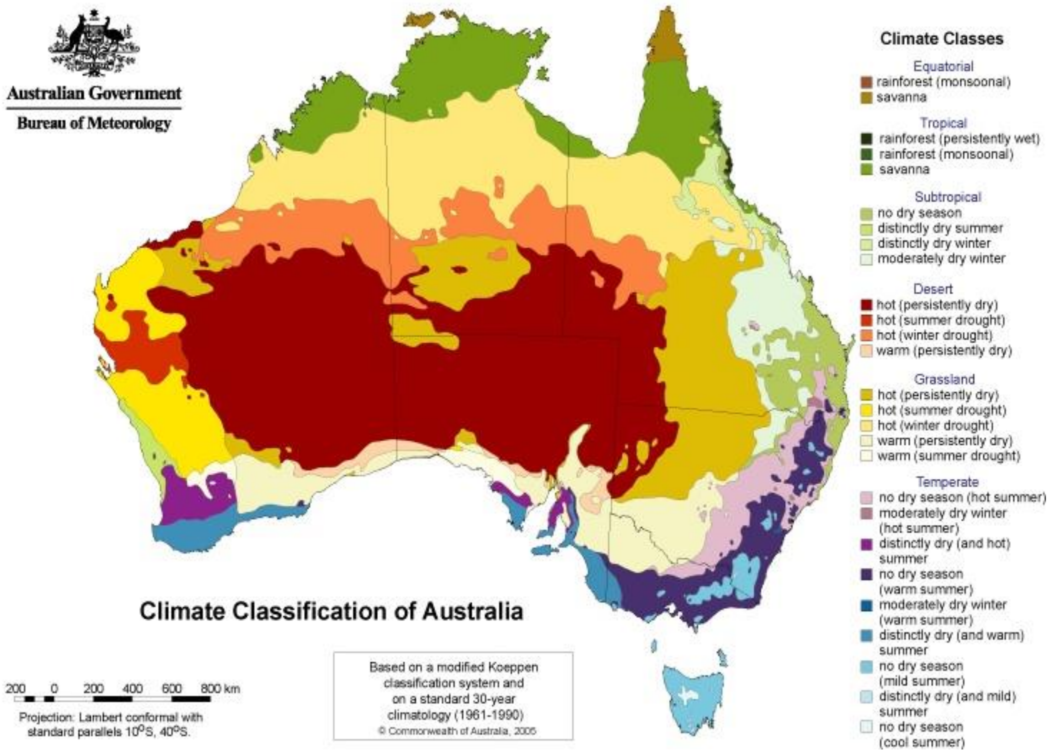


Acronyms and abbreviations

Term or abbreviation	Definition
ACT	Australian Capital Territory
ALOP	Appropriate level of protection
BICON	Australia's Biosecurity Import Conditions database
BIRA	Biosecurity Import Risk Analysis
BQA	Bilateral quarantine arrangement
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EP	Existing policy
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia New Zealand
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NSW	New South Wales
NPPO	National Plant Protection Organisation
NT	Northern Territory
PRA	Pest risk analysis
Qld	Queensland
SA	South Australia
SPS Agreement	WTO agreement on the Application of Sanitary and Phytosanitary Measures
Tas.	Tasmania
The department	The Australian Government Department of Agriculture
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organization

Summary

This risk analysis report considers the biosecurity risks for Australia associated with the importation of commercially produced fresh breadfruit for human consumption from Fiji, Samoa and Tonga.

Currently, the importation of fresh breadfruit for human consumption is not permitted into Australia.

This final report recommends that the importation of fresh breadfruit to Australia from all commercial production areas in Fiji, Samoa and Tonga be permitted, subject to it meeting a range of biosecurity requirements as summarised in this report.

This final report contains details of all known pests with the potential to be associated with the importation of breadfruit from Fiji, Samoa and Tonga that may be of biosecurity concern to Australia. It also provides risk assessments for the identified quarantine pests and recommends risk management measures to reduce the biosecurity risk to an acceptable level.

Seven arthropod pests have been identified in this risk analysis as requiring risk management measures. Those pests are:

- Fruit flies: fruit fly (*Bactrocera facialis*), Fijian fruit fly (*Bactrocera passiflorae*) and Pacific fruit fly (*Bactrocera xanthodes*).
- Mealybugs: grey pineapple mealybug (*Dysmicoccus neobrevipes*), mealybug (*Dysmicoccus nesophilus*), Pacific mealybug (*Planococcus minor*) and cryptic mealybug (*Pseudococcus cryptus*).

These identified pests are the same, or of the same pest groups, as those associated with other horticultural commodities that have been assessed previously by the department.

The recommended risk management measures take account of regional differences within Australia. Two pests, Pacific mealybug (*Planococcus minor*) and cryptic mealybug (*Pseudococcus cryptus*), have been identified as regional quarantine pests for Western Australia because interstate quarantine regulations and enforcement are in place for these species.

This final report recommends risk management measures, combined with an operational system, to ensure biosecurity standards are met. The recommended risk management measures will reduce the risks posed by the seven identified quarantine pests, so as to achieve the appropriate level of protection for Australia. These measures are:

- high temperature forced air treatment, or gamma irradiation treatment for fruit flies
- pre-export visual inspection and, if found, remedial action for mealybugs.

Upon finalisation of this policy, Fiji, Samoa and Tonga must be able to demonstrate to the department that processes and procedures are in place to implement the recommended risk management measures. This will ensure safe trade in fresh breadfruit from these countries. Import conditions can then be published in the Australian Government's biosecurity import conditions (BICON) database on the department's website, which can be accessed at: bicon.agriculture.gov.au/BiconWeb4.0.

Written submissions on the draft report were received from two stakeholders. The department has made a number of changes to the report following consideration of technical comments from stakeholders and subsequent review of the literature. These changes include:

- amendments to the text of Chapter 3: 'Commercial production practices for breadfruit', to provide further clarity that it is a requirement of the respective National Plant Protection Organisations (NPPOs) of Fiji, Samoa and Tonga that all orchards intending to export breadfruit are to be registered.
- amendments to the text of Chapter 3: 'Commercial production practices for breadfruit', to clarify that there are high temperature forced air (HTFA) treatment facilities located in Fiji, Samoa and Tonga.
- amendments to the text of Chapter 5: 'Pest risk management', to clarify that breadfruit are sourced only from orchards located in Fiji, Samoa and Tonga.
- addition of Appendix B: 'Issues raised in stakeholder comments' which summarises key technical comments from stakeholders, and how technical issues were considered by the department in this final report.
- minor corrections, rewording and editorial changes for consistency, clarity and web-accessibility.

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The risk analysis process is an important part of Australia's biosecurity policy development. It enables the Australian Government to formally consider the level of biosecurity risk that may be associated with proposals to import goods into Australia. If the biosecurity risks do not achieve the appropriate level of protection (ALOP) for Australia, risk management measures are recommended to reduce the risks to an acceptable level. If the risks cannot be reduced to an acceptable level, the goods will not be imported into Australia until suitable measures are identified.

Successive Australian governments have maintained a stringent, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of the ALOP for Australia, which is defined in the *Biosecurity Act 2015* as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's risk analyses are undertaken by the Department of Agriculture using technical and scientific experts in relevant fields, and involve consultation with stakeholders at various stages during the process.

Risk analyses may take the form of a biosecurity import risk analysis (BIRA) or a review of biosecurity import requirements (such as a scientific review of existing policy or import conditions, a pest-specific assessment, a weed risk assessment, an assessment of a biological control agent, or other scientific advice).

Further information about Australia's biosecurity framework is provided in the *Biosecurity Import Risk Analysis Guidelines 2016* located on the Department of Agriculture website at http://www.agriculture.gov.au/biosecurity/risk-analysis/guidelines.

1.2 This risk analysis

1.2.1 Background

Fiji initially sought market access for fresh breadfruit to Australia in 1994. Market access for fresh breadfruit was again formally requested in June 2015. Additional information on breadfruit production, pest management, existing export protocols for breadfruit exports to New Zealand, and phytosanitary treatments was provided in December 2017.

Samoa wrote to the department in 2002 requesting market access for fresh breadfruit, and provided a list of pests associated with breadfruit in Samoa. A further submission was received in 2007, which included information on the pests and typical commercial production practices. The department considered a separate proposal for baked breadfruit from Samoa, which was approved in 2012. Import requirements for baked breadfruit from Samoa can be found in the department's Biosecurity Import Conditions (BICON) database, which can be accessed at: bicon.agriculture.gov.au/BiconWeb4.0.

Tonga previously registered interest in exporting breadfruit to Australia, reaffirmed in June 2016, but has not provided a formal submission.

Fiji, Samoa and Tonga currently have access to export fresh breadfruit to New Zealand, under protocols that require a high temperature forced air (HTFA) treatment to mitigate the risks posed by fruit fly pests.

On 15 August 2017, the department announced the commencement of this risk analysis, advising that it would be progressed as a review of biosecurity import requirements. This analysis is conducted in accordance with Section 174 of the *Biosecurity Act 2015*.

1.2.2 Description of breadfruit

Breadfruit, *Artocarpus altilis* (Parkinson ex F.A. Zorn) Fosberg, is a member of the Moraceae (mulberry and fig) plant family. The genus *Artocarpus* consists of approximately 60 species native to the Indian subcontinent, south-east Asia and Australasia (Zerega, Ragone & Motley 2004), including breadfruit (*A. altilis*) and jackfruit (*A. heterophyllus*). Breadfruit has been cultivated for thousands of years in Oceania, and hundreds of cultivars have been developed, many of which are seedless and vegetatively propagated (Zerega, Ragone & Motley 2004). Cultivated breadfruit likely originated in Papua New Guinea from wild breadnut, *Artocarpus camansi*, with human migration dispersing the plant throughout Melanesia, and subsequently into Polynesia and Micronesia. Some cultivars in Micronesia also hybridised with the native *Artocarpus mariannensis* present in Palau and the Mariana Islands. Few of these hybrid cultivars have been introduced to Melanesia and Polynesia (Zerega, Ragone & Motley 2004).

The breadfruit tree is typically 12–15 metres tall, with a trunk around 30 centimetres to one metre in diameter and a spreading evergreen canopy of large dark green leaves (Ragone 2006, 2011). However, trees grown specifically for commercial fruit production are typically pruned to a height of 4–5 metres to reduce the need for climbing to harvest the fruit (Figure 1).

The breadfruit fruit (Figure 2) is a syncarp, a fleshy compound fruit formed from a cluster of around 1500–2000 tiny flowers (Ragone 1997). Depending on the variety, the fruit are variable in size, shape and surface texture. They are usually round, oval or oblong in shape, around 9–20 centimetres wide, and can be more than 30 centimetres long (Ragone 2011). They typically weigh around 1–4 kilograms (Duke & duCellier 1993), depending on the variety.

The skin is tough, and patterned with pentagonal, hexagonal or heptagonal markings, each being the surface of an individual flower. The fruit surface may be smooth or slightly bumpy, and some varieties have small spines (Ragone 1997). Milky white latex is present in all parts of the tree, and the fruit rind is usually stained with latex exudations when mature (Ragone 1997).

Figure 1 Breadfruit orchard, Upolu, Samoa

Figure 2 Breadfruit, Upolu, Samoa

Depending on the cultivar, the fruit may be seedless, or have few or many seeds, which are edible. Seeds have little or no endosperm, and germinate immediately. They are susceptible to desiccation, so cannot be stored (Ragone 1997). The fruit is edible at all stages of development, and can be consumed either as a vegetable or a starch, depending on what stage at which it is harvested.

The immature fruit are bright green in colour. Immature fruit lack the starch, creamy texture and rich flavour of ripe fruit, and must be cooked before consumption. Immature fruit have a longer shelf life, but they do not ripen further once harvested. The firm immature flesh is used for making chips, or cooked and eaten as a vegetable (Elevitch, Ragone & Cole 2014).

Consumer preference is for mature, but not yet ripe, fruit. These comprise the bulk of fresh breadfruit sold in the market, and have the highest value (Elevitch, Ragone & Cole 2014). Mature fruit have potato-like starchy qualities, and can be used for curries, stews, fries and salads, and are also used in many processed products.

As the breadfruit ripens, the starches are gradually converted to sugars, and the fruit can be eaten raw, or used for many types of desserts. Fully ripe breadfruit has very soft flesh, and emits a sweet, fruity fragrance (Elevitch, Ragone & Cole 2014). Fruit at this stage has a short shelf-life of only a couple of days, which does not allow sufficient time for export to overseas markets (NWC 2005).

1.2.3 Scope

This risk analysis considers the biosecurity risks associated with the importation of fresh breadfruit (*Artocarpus altilis*) into Australia from Fiji, Samoa and Tonga for human consumption. The scope is restricted to fresh breadfruit grown in Fiji, Samoa and Tonga using commercial production, harvesting and packing practices considered to be typical for the export of fresh breadfruit from these countries. Unless otherwise indicated, in this report the term breadfruit is used to refer specifically to the fruit of the breadfruit tree.

For the purposes of this risk analysis, breadfruit are defined as whole fresh, mature green fruit, which may have a portion of stem (up to 10 cm) attached. This risk analysis covers all varieties of commercially-produced breadfruit grown on any island or region of Fiji, Samoa and Tonga.

1.2.4 Existing policy

International policy

The importation of fresh breadfruit into Australia is currently not permitted from any country. However, there are established import conditions for a number of other fresh fruit commodities from Fiji, Samoa and Tonga. The potential pests of biosecurity concern identified for breadfruit from Fiji, Samoa and Tonga are the same as, or similar to, the pests of other commodities for which import conditions exist.

There is also existing import policy for baked breadfruit from Samoa. The import requirements for this commodity can be found in the department's biosecurity import conditions database (BICON) at: https://bicon.agriculture.gov.au/BiconWeb4.0.

Domestic arrangements

The Australian Government is responsible for regulating the movement of goods such as plants and plant products into and out of Australia. However, the state and territory governments are responsible for plant health controls within their individual jurisdictions. Legislation relating to resource management or plant health may be used by state and territory government agencies to control interstate movement of plants and their products. Once plants and plant products have been cleared by Australian Government biosecurity officers, they may be subject to interstate movement regulations/arrangements. It is the importer's responsibility to identify and ensure compliance with all requirements.

1.2.5 Contaminating pests

In addition to the pests of breadfruit from Fiji, Samoa and Tonga that are assessed in this risk analysis, there are other organisms that may arrive with the imported commodity. These organisms could include pests of other crops, or predators and parasitoids of other arthropods. The department considers these organisms to be contaminating pests that could pose sanitary risks (to human or animal life or health) or phytosanitary risks (to plant life or health). These risks are identified and addressed by existing operational procedures that require a 600-unit inspection of all consignments on arrival, or equivalent procedures. The department will investigate whether any pest identified through these processes may be of biosecurity concern to Australia, and may thus require remedial action.

1.2.6 Consultation

On 15 August 2017, the department notified stakeholders, in Biosecurity Advice 2017/15, of the commencement of a review of biosecurity import requirements for fresh breadfruit from Fiji, Samoa and Tonga.

The department consulted with the NPPOs of the exporting countries and Australian state and territory governments during the preparation of this report.

The draft report was released on 4 October 2018 (Biosecurity Advice 2018/25) for comment by stakeholders, for a period of 60 days that concluded on 3 December 2018.

The department received two written submissions on the draft report. All submissions received, and issues raised by domestic stakeholders during consultation of the draft report, were carefully considered, and, where relevant, changes were made in the final report. A summary of the key technical stakeholder comments and how they were considered is provided in Appendix B.

1.2.7 Next Steps

The final report will be published on the department's website, along with a notice advising stakeholders of its release. The department will also notify the respective NPPOs, the registered stakeholders and the WTO Secretariat about the release of the final report. Publication of the final report represents the end of the risk analysis process.

The biosecurity requirements recommended in the final report will form the basis of the conditions published in the Biosecurity Import Conditions (BICON) system and subsequently for any import permits issued. Before any trade in breadfruit from Fiji, Samoa and Tonga commences, the department will verify that Fiji, Samoa and Tonga can implement the required pest risk management measures, and the system of operational procedures necessary to maintain and verify the phytosanitary status of breadfruit for export to Australia from Fiji, Samoa and Tonga (as specified in Chapter 5: Pest risk management of this report). On verification of these requirements, the import conditions for breadfruit from Fiji, Samoa and Tonga will be published in the department's Biosecurity Import Conditions (BICON) system. Applications for import permits can then be made online through BICON.

2 Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Department of Agriculture has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2016a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2017a) that have been developed under the SPS Agreement (WTO 1995).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it' (FAO 2019). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2019). This definition is also applied in the *Biosecurity Act 2015*.

Biosecurity risk consists of two major components: the likelihood of a pest entering, establishing and spreading in Australia from imports; and the consequences should this happen. These two components are combined to give an overall estimate of the risk.

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, the department will verify that the consignment received is as described on the commercial documents and its integrity has been maintained.

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2019).

A glossary of the terms used in the risk analysis is provided at the end of this report.

The PRA is conducted in the following three consecutive stages: initiation, pest risk assessment and pest risk management.

2.1 Stage 1 Initiation

Initiation identifies the pest(s) and pathway(s) that are of biosecurity concern and should be considered for risk analysis in relation to the identified PRA area.

Appendix A of this risk analysis report lists the pests with the potential to be associated with the exported commodity produced using commercial production and packing procedures. Appendix A does not present a comprehensive list of all the pests associated with the entire plant, but concentrates on the pests that could be on the assessed commodity. Contaminating pests that have no specific relation to the commodity or the export pathway have not been listed and would be addressed by Australia's current approach to contaminating pests.

The identity of the pests is given in Appendix A. The species name is used in most instances but a lower taxonomic level may be used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting country's National Plant Protection Organisation (NPPO) or where the cited literature used a different scientific name.

For this risk analysis, the 'PRA area' is defined as Australia for pests that are absent, or of limited distribution and under official control. For areas with regional freedom from a pest, the 'PRA area' may be defined on the basis of a state or territory of Australia or may be defined as a region of Australia consisting of parts of a state or territory or several states or territories.

For pests that had been considered by the department in other risk assessments and for which import conditions already exist, this risk analysis considered the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, previous risk assessments were taken into consideration in this risk analysis.

2.2 Stage 2 Pest risk assessment

A pest risk assessment (for quarantine pests) is the 'evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences' (FAO 2019).

The following three, consecutive steps were used in pest risk assessment:

2.2.1 Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A 'quarantine pest' is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2019).

The pests identified in Stage 1 were categorised using the following primary elements to identify the quarantine pests for the commodity being assessed:

- identity of the pest
- presence or absence in the PRA area
- regulatory status
- potential for establishment and spread in the PRA area
- potential for economic consequences (including environmental consequences) in the PRA area.

The results of pest categorisation are set out in Appendix A. The quarantine pests identified during categorisation were carried forward for pest risk assessment and are listed in Table 4.1.

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11(FAO 2017a). The SPS Agreement (WTO 1995) uses the term likelihood rather than probability for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of entry, establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

A summary of this process is given below, followed by a description of the qualitative methodology used in this risk analysis.

Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

The likelihood of entry estimates for the quarantine pests for a commodity are based on the use of the existing commercial production, packaging and shipping practices of the exporting country. Details of the existing commercial production practices for the commodity are set out in Chapter 3. These practices are taken into consideration by the department when estimating the likelihood of entry.

For the purpose of considering the likelihood of entry, the department divides this step into two components:

- **Likelihood of importation**—the likelihood that a pest will arrive in Australia when a given commodity is imported.
- **Likelihood of distribution**— the likelihood that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors to be considered in the likelihood of importation may include:

- distribution and incidence of the pest in the source area
- occurrence of the pest in a life-stage that would be associated with the commodity
- mode of trade (for example, bulk or packed in individual cartons)
- volume and frequency of movement of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin
- speed of transport and conditions of storage compared with the duration of the lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence of the pest likely to be associated with a consignment
- commercial procedures (for example, refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors to be considered in the likelihood of distribution may include:

- commercial procedures (for example, refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a host

- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to hosts
- time of year at which import takes place
- intended use of the commodity (for example, for planting, processing or consumption)
- risks from by-products and waste.

Likelihood of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2019). In order to estimate the likelihood of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology, survival) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the likelihood of establishment.

Factors to be considered in the likelihood of establishment in the PRA area may include:

- availability of hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

Likelihood of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2019). The likelihood of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the likelihood of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the likelihood of spread.

Factors to be considered in the likelihood of spread may include:

- suitability of the natural and/or managed environment for natural spread of the pest
- presence of natural barriers
- potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 2.1). Definitions for these descriptors and their indicative probability ranges are given in Table 2.1. The indicative probability ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative probability ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table 2.1 Nomenclature of likelihoods

Likelihood	Descriptive definition	Indicative range
High	The event would be very likely to occur	0.7 < to ≤ 1
Moderate	The event would occur with an even likelihood	0.3 < to ≤ 0.7
Low	The event would be unlikely to occur	0.05 < to ≤ 0.3
Very low	The event would be very unlikely to occur	0.001 < to ≤ 0.05
Extremely low	The event would be extremely unlikely to occur	0.000001 < to ≤ 0.001
Negligible	The event would almost certainly not occur	0 < to ≤ 0.000001

Combining likelihoods

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table 2.2). This matrix is then used to combine the likelihood of entry and the likelihood of establishment, and the likelihood of entry and establishment is then combined with the likelihood of spread to determine the overall likelihood of entry, establishment and spread.

Table 2.2 Matrix of rules for combining likelihoods

	High	Moderate	Low	Very low	Extremely low	Negligible
High	High	Moderate	Low	Very low	Extremely low	Negligible
Moderate		Low	Low	Very low	Extremely low	Negligible
Low			Very low	Very low	Extremely low	Negligible
Very low				Extremely low	Extremely low	Negligible
Extremely low					Negligible	Negligible
Negligible						Negligible

For example, if the likelihood of importation is assigned a descriptor of 'low' and the likelihood of distribution is assigned a descriptor of 'moderate', then they are combined to give a likelihood of 'low' for entry. The likelihood for entry is then combined with the likelihood assigned for establishment of 'high' to give a likelihood for entry and establishment of 'low'. The likelihood for entry and establishment is then combined with the likelihood assigned for spread of 'very low' to give the overall likelihood for entry, establishment and spread of 'very low'. This can be summarised as:

importation x distribution = entry [E]	**low x moderate = low**
entry x establishment = [EE]	**low x high = low**
[EE] x spread = [EES]	**low x very low = very low**

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as trade continues and the overall volume of trade accumulates.

The department normally considers the likelihood of entry on the basis of the estimated volume of one year's trade. This is a convenient value for the analysis that is relatively easy to estimate and allows for expert consideration of seasonal variations in pest presence, incidence and behaviour to be taken into account. The consideration of the likelihood of entry, establishment and spread and subsequent consequences takes into account events that might happen over a number of years even though only one year's volume of trade is being considered. This difference reflects biological and ecological facts, for example where a pest or disease may establish in the year of import but spread may take many years.

These considerations have been taken into account when setting up the matrix. Therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on the department's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. If there are substantial changes in the volume and nature of the trade in specific commodities then the department will review the risk analysis and, if necessary, provide updated policy advice.

In considering the volume of trade in this risk analysis, the department has concluded that a relatively low volume of trade in breadfruit is likely to occur. Based on current production levels and export pathways, it is not anticipated that trade would likely exceed 30 tonnes per year.

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the potential consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2019) and ISPM 11 (FAO 2017a).

Direct pest effects are considered in the context of the effects on:

- plant life or health
- other aspects of the environment.

Indirect pest effects are considered in the context of the effects on:

- eradication, control
- domestic trade
- international trade
- environment.

For each of these six criteria, the consequences were estimated over four geographic levels, defined as:

Local—an aggregate of households or enterprises (a rural community, a town or a local government area).

District—a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').

Regional—a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).

National—Australia wide (Australian mainland states and territories and Tasmania).

For each criterion, the magnitude of the potential consequence at each of these levels was described using four categories, defined as:

Indiscernible—pest impact unlikely to be noticeable.

Minor significance—expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.

Significant—expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.

Major significance—expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic 'value' of non-commercial criteria.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A-G) using Table 2.3. For example, a consequence with a magnitude of 'significant' at the 'district' level will have a consequence impact score of D.

Table 2.3 Decision rules for determining the consequence impact score

	Geographic scale			
Magnitude	Local	District	Region	Nation
Indiscernible	A	A	A	A
Minor significance	B	C	D	E
Significant	C	D	E	F
Major significance	D	E	F	G

Note: In earlier qualitative PRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A to F has been changed to become B-G and a new lowest category A ('indiscernible' at all four levels) was added. The rules for combining impacts in Table 2.4 were adjusted accordingly.

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 2.4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

Table 2.4 Decision rules for determining the overall consequence rating for each pest

Rule	The impact scores for consequences of direct and indirect criteria	Overall consequence rating
1	Any criterion has an impact of 'G'; or more than one criterion has an impact of 'F'; or a single criterion has an impact of 'F' and each remaining criterion an 'E'.	Extreme
2	A single criterion has an impact of 'F'; or all criteria have an impact of 'E'.	High
3	One or more criteria have an impact of 'E'; or all criteria have an impact of 'D'.	Moderate
4	One or more criteria have an impact of 'D'; or all criteria have an impact of 'C'.	Low
5	One or more criteria have an impact of 'C'; or all criteria have an impact of 'B'.	Very Low
6	One or more but not all criteria have an impact of 'B', and all remaining criteria have an impact of 'A'.	Negligible

2.2.4 Estimation of the unrestricted risk

Once the assessment of the likelihood of entry, establishment and spread and for potential consequences are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 2.5) to combine the estimates of the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the combination of likelihood and consequence.

Table 2.5 Risk estimation matrix

Likelihood of pest entry, establishment and spread	Consequences of pest entry, establishment and spread					
	Negligible	Very low	Low	Moderate	High	Extreme
High	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (for example, low, moderate, high) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a 'low' likelihood combined with 'high' consequences, is not the same as a 'high' likelihood combined with 'low' consequences—the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of 'moderate', whereas, the latter would be rated as a 'low' unrestricted risk.

2.2.5 The appropriate level of protection (ALOP) for Australia

The SPS Agreement defines the concept of an 'appropriate level of sanitary or phytosanitary protection (ALOP)' as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. The ALOP for Australia, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 2.5 marked 'very low risk' represents the ALOP for Australia.

2.2.6 Adoption of outcomes from previous assessments

Outcomes of previous risk assessments have been adopted in this assessment for pests for which the risk profile is assessed as comparable to previously assessed situations.

The prospective adoption of previous risk assessment ratings is considered on a case-by-case basis by comparing factors relevant to the current commodity/country pathway with those assessed previously. For assessment of the likelihood of importation, factors considered/compared include the commodity type, the prevalence of the pest and commercial production practices, whereas for assessment of the likelihood of distribution of a pest the factors include the commodity type, the time of year when importation occurs, and the availability and susceptibility of hosts at that time. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihoods to be comparable to those assigned in the previous assessment(s).

The likelihood of establishment and of spread of a pest species in the PRA area (in this instance, Australia) will be comparable between risk assessments, regardless of the commodity/country pathway through which the pest is imported, as these likelihoods relate specifically to conditions and events that occur in the PRA area, and are independent of the importation pathway. Similarly, the estimate of potential consequences associated with a pest species is also independent of the importation pathway. Therefore, the likelihoods of establishment and of spread of a pest, and the estimate of potential consequences, are directly comparable between assessments, and may be adopted with confidence.

The *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut flower and foliage imports* was finalised in January 2019. As the group policy was finalised after the release of the draft report for breadfruit from Fiji, Samoa and Tonga, and conclusion of the stakeholder comment period, the group policy was not adopted for this risk analysis. However, its assessments and recommended risk management measures are consistent with the present analysis.

2.3 Stage 3 Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve the ALOP for Australia, while ensuring that any negative effects on trade are minimised.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate does not achieve the ALOP for Australia, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve the ALOP for Australia. The effectiveness of any recommended phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure the restricted risk for the relevant pest or pests achieves the ALOP for Australia.

ISPM 11 (FAO 2017a) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the likelihood of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

- options for consignments—for example, inspection or testing for freedom from pests, prohibition of parts of the host, a pre-entry or post-entry quarantine system, specified conditions on preparation of the consignment, specified treatment of the consignment, restrictions on end-use, distribution and periods of entry of the commodity
- options preventing or reducing infestation in the crop—for example, treatment of the crop, restriction on the composition of a consignment so it is composed of plants belonging to resistant or less susceptible species, harvesting of plants at a certain age or specified time of the year, production in a certification scheme
- options ensuring that the area, place or site of production or crop is free from the pest—for example, pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways—for example, consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery
- options within the importing country—for example, surveillance and eradication programs
- prohibition of commodities—if no satisfactory measure can be found.

Risk management measures are identified for each quarantine pest where the level of biosecurity risk does not achieve the ALOP for Australia. These are presented in the pest risk management section of this report (Chapter 5).

3 Commercial production practices for breadfruit

This chapter provides information on pre-harvest, harvest and post-harvest practices, considered to be typical of practices in Fiji, Samoa and Tonga for the commercial production of fresh breadfruit for export. The export capabilities of these countries is also outlined.

3.1 Considerations used in estimating unrestricted risk

Fiji and Samoa provided Australia with information on the typical commercial practices used in the production of breadfruit for export. This information was complemented with data from other sources and was taken into consideration when estimating the unrestricted risks of pests that may be associated with the import of this commodity.

Officers from the department visited breadfruit production areas in Fiji in 2017 and Samoa in 2012 to observe commercial breadfruit production, pest management and other export practices. Observations of high temperature forced air (HTFA) treatments and packing of fresh breadfruit for export to New Zealand were also undertaken in Fiji in 2018 and in Tonga in 2011. The department's observations and additional information provided during these visits confirmed the production, processing and export procedures described in this chapter as typical commercial production practices for fresh breadfruit for export.

In estimating the likelihood of pest introduction it was assumed that the pre-harvest, harvest and post-harvest production practices for breadfruit, including in-field control measures to reduce fruit fly prevalence, as described in this chapter are implemented for all regions within the scope of this analysis.

When assessing the likelihood of entry, it was assumed trade volumes would be relatively modest for the foreseeable future.

3.2 Breadfruit production in Fiji, Samoa and Tonga

Fiji, Samoa and Tonga are small island nations in the South Pacific (Figure 3). These countries all have a tropical maritime climate, with distinct wet and dry seasons. The wet season is typically from November to April, with the dry season from May to October. Within each country there are local climatic variations that can affect their suitability for growing particular crops. This is due to the prevailing trade winds and mountainous terrain, and the different latitudes of the islands, particularly those with archipelagos spread over vast areas such as Tonga. Breadfruit thrives in hot, humid tropical lowlands (Ragone 1997), which are common in the coastal areas of these countries.

Fiji

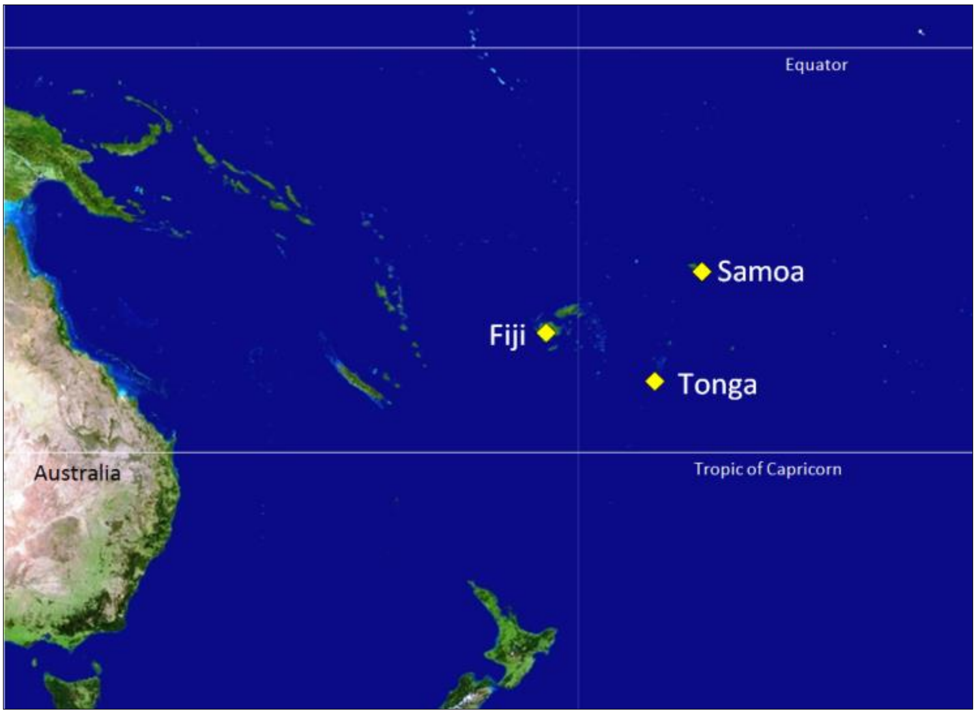
The Republic of Fiji is located in the Melanesia region of the western Pacific between New Caledonia and Samoa. It is an archipelago of around 110 inhabited islands, as well as many uninhabited islands and islets. The islands of Viti Levu, Vanua Levu and Taveuni produce the majority of the agricultural commodities for export markets, including taro, copra, sugar and ginger.

Breadfruit is commonly known as utu or buco in Fiji. It is a minor seasonal food staple in Fiji, being less popular than taro, cassava and sweet potato. At least 70 named breadfruit varieties have been identified in Fiji (Morton 1987). The main commercial varieties grown for export in Fiji are Uto dina and Bale kana (NWC 2005).

Breadfruit production in Fiji is on a small scale, and until relatively recently was predominantly in backyards, around villages or harvested from forested areas. Export production is now mostly undertaken in specific orchards, commonly in a linear layout, with trees planted in a single row along a property boundary or road, and often intercropped with other plants such as sandalwood and cassava. Existing farms commonly have around 50–200 trees in production. Fiji requires that all orchards intending to export fruit be registered by the Fiji Ministry of Agriculture. As of May 2017, Fiji had over 1400 breadfruit trees in production for export (Biosecurity Authority Fiji 2017).

The main production areas for export are located on the island of Viti Levu, specifically in Vaivai (near Lautoka), Bila Levu (near Nadi), and Mavua (in the Sigatoka Valley). These are all relatively close to Nadi's international airport and commercial HTFA treatment facility. Fiji has exported breadfruit to New Zealand since 2000, but volumes are small, usually 10–13 tonnes per year.

Figure 3 Location of Pacific Island countries considered in this report



Map source: NASA

Samoa

Samoa has two main islands, Upolu and Savai'i, as well as a number of smaller islands and islets. The United States territory of American Samoa, which lies to the east of Upolu, is not part of the Independent State of Samoa (previously known as Western Samoa), and is not considered in this assessment. The Samoan islands are volcanic in origin, with a narrow coastal plain and rugged mountainous interior. Much of the population is involved in subsistence agriculture, with the main commodities grown being coconuts, bananas, taro, yams, coffee and cocoa, with only small export volumes.

Breadfruit is a culturally important food in Samoa, where it is traditionally known as ʻulu. The most common commercially grown varieties are Maopo, Puo'u, Ma'afala and Momolega (MAF 2007). Samoa has had market access for exporting fresh breadfruit to New Zealand, using HTFA treatment since 2004, although little trade has occurred in recent years. Samoa requires that all orchards, packing houses and treatment facilities intending to export fruit be registered by the Samoa Ministry of Agriculture and Fisheries. Breadfruit exported to New Zealand are treated in the HTFA treatment facility and packing house accredited for export, which is located at the Atele Horticultural Centre, near the capital, Apia.

Tonga

Tonga is an archipelago of 176 islands to the south of Samoa. The islands are sparsely spread across 700,000 km^2 of the South Pacific in two parallel chains running north to south. The islands are administratively divided into three groups – the Vava'u group in the north, the Ha'apai group in the centre, and the Tongatapu group in the south. The majority of the population lives on the island of Tongatapu, where the capital Nuku'alofa and main commercial hub are situated. The only HTFA treatment facility is located adjacent to the Fuaʻamotu International Airport, on Tongatapu.

Breadfruit production in Tonga is still predominantly on a small scale, with breadfruit trees typically intercropped amongst other trees, or planted along the farm perimeter. The main variety of breadfruit grown in Tonga for export is Puo'u. Tonga's Ministry of Agriculture, Food, Forests and Fisheries operates a nursery that supplies breadfruit plants to growers.

Tonga has had market access for exporting fresh breadfruit to New Zealand for many years, using HTFA treatment. Tonga requires that all orchards intending to export fruit to be registered by the Ministry of Agriculture, Food, Forests and Fisheries. Breadfruit exported to New Zealand is treated in the only HTFA treatment facility in Tonga, which is located adjacent to the Fuaʻamotu International Airport, on Tongatapu.

3.3 Pre-harvest

3.3.1 Cultivars

Despite the significant diversity in breadfruit varieties in the Pacific Islands, only a few cultivars are grown commercially for export. The main ones are Puo'u, Ma'afala and Uto dina.

Puo'u is a Polynesian variety that has been distributed widely throughout Polynesia, Micronesia and Melanesia, and has also been introduced to Australia. The trees are relatively small, up to 10 metres tall, with a dense, spreading canopy (Ragone 2006). The fruit are round, oval or heart-shaped, and 1.2 to 2.4 kilograms in weight (the average weight is around 1.5 kilograms). This is a seedless variety, although one or more seeds may occasionally be present (Ragone 2006).

Ma'afala (known as Bale Kana in Fiji) is another popular Polynesian variety grown in Samoa, Tonga and Fiji, and many other Pacific Island countries, as well as Australia. The trees are smaller and more compact than most varieties, and produce smaller fruits. Fruit are oval in shape, around 12 to 16 centimetres long and weighing 0.6 to 1.1 kilograms (the average weight is around 800 grams). This is a seedless variety, although one or more seeds may occasionally be present (Elevitch, Ragone & Cole 2014).

Uto dina is a Fijian seedless variety with a round to slightly oval fruit shape. Uto dina fruit harvested for export are usually 11 to 14 centimetres in length. Larger fruit may be exported, but typically do not exceed two kilograms (NWC 2005). The skin is slightly rough to smooth when the fruit is mature. It does not require peeling after cooking, and is the most popular variety grown in Fiji (NWC 2005).

3.3.2 Cultivation practices

Breadfruit trees can be propagated from root shoots or root cuttings, or by air layering branches (marcotting)(Ragone 1997).

New shoots, also known as suckers, emerge from mature breadfruit tree roots growing close to the soil surface. Some varieties, such as Puo'u in Samoa and bale kana in Fiji, have a greater tendency to produce suckers (MAF 2007; NWC 2005). Sucker growth can be induced by wounding the roots. The shoot can be cut from the parent tree once the stem becomes woody and lobed leaves emerge, usually when shoots are around 20–25 centimetres tall (MAF 2007). The root is cut around 10 centimetres on either side of the sucker, and this section of root and shoot can then be transferred to the nursery. Cuttings are usually transferred to pots or bags, where they are kept until they are around 60 centimetres high (MAF 2007), but may be planted directly in the field (NWC 2005). In Fiji, growers typically purchase young trees from commercial nurseries (Figure 4).

Figure 4 Young breadfruit trees in a nursery ready for planting, Nadi, Fiji

Young breadfruit trees are planted in holes in the field, spaced around 8–12 metres apart, usually with around 85 trees per hectare (MAF 2007). Wider spacing is preferable, as it allows for intercropping between the rows of breadfruit trees (MAF 2007).

Asexually propagated breadfruit trees start fruiting in three to six years (Ragone 1997). Pruning of trees after fruiting is recommended to stimulate growth of new shoots, and prevent the trees becoming too tall, which can make harvesting the fruit difficult (MAF 2007; Ragone 1997).

3.3.3 Pest management

Fiji, Samoa and Tonga undertake an integrated approach to managing fruit flies for the export of fresh breadfruit. Each country has established a surveillance trapping system to monitor for introduction of exotic fruit flies, with a network of traps around ports of entry, residential areas, resorts, research stations and rubbish dumps. To complement the surveillance trapping, host fruit collections are also carried out periodically to monitor for presence of exotic fruit fly species that are not attracted to male lures (Tupou et al. 2001).

Field trapping is also undertaken to monitor pest levels at farm level, with methyl eugenol and cue-lure traps (Figure 5) installed in breadfruit orchards (MAF 2007). The fruit fly pests of breadfruit present in the assessed countries are responsive to either cue-lure (*Bactrocera facialis* and *Bactrocera passiflorae*) or methyl eugenol (*Bactrocera xanthodes*) (Tupou et al. 2001; White & Elson-Harris 1994).

Figure 5 Fruit fly traps, breadfruit orchard, Nadi, Fiji

Field sanitation measures are also undertaken, with ripe and fallen breadfruit removed from the field and disposed of (either buried or burned) to reduce the resident fruit fly population and prevent infestation. Mature green breadfruit are typically not attractive to fruit flies, but overripe and fallen fruit can provide a major source of infestation, reducing the efficacy of other control measures such as protein bait sprays.

Fiji, Samoa and Tonga also implement bait spraying programs as part of their existing bilateral quarantine arrangements for market access to New Zealand. The protein bait (usually yeast and water mixed with malathion insecticide) is sprayed onto the underside of the leaves each week for a period of seven weeks prior to harvest (NWC 2005). Pesticides are not typically applied to control other pests. However, pests such as mealybugs and scales may be physically removed by wiping or washing the fruit after harvest (NWC 2005).

3.4 Harvesting and handling procedures

Breadfruit is usually picked when mature, but not ripe (Ragone 2011). For export, it is harvested at slightly less than full maturity, best described as ‘mature green’ (NWC 2005), which is considered to be less susceptible to fruit fly attack. The breadfruit are usually harvested with a sharp scythe or curved knife attached to the end of a long, sturdy pole. The detached fruit are usually caught in a tarpaulin held above the ground (NWC 2005). A net may be attached to the pole to catch the fruit to prevent bruising (Ragone 1997). Breadfruit are placed in plastic crates for transport to the packing house.

3.5 Post-harvest

3.5.1 Packing house and export procedures

Fruit are washed with a soft sponge and running water to remove sap, which oozes from the stem when the fruit is harvested (MAF 2007). Some exporters may keep the fruit immersed in cool water overnight to prevent premature softening (NWC 2005). The fruit are sorted and graded in the packing house, undergoing a quality control check to remove any fruit with visible defects (sunburn, cuts, bruises, excessive sap stains), and shape malformations (NWC 2005). The optimal fruit size for export from Fiji is between 10 and 17 centimetres diameter, depending on the variety.

Breadfruit destined for export to New Zealand require a phytosanitary inspection be undertaken by the NPPO prior to treatment. This inspection is conducted at the exporter's packing house. Crates are weighed and secured, and details are recorded on an official transfer slip to ensure the integrity of the consignment is maintained. The existing export pathway also requires phytosanitary treatment (high temperature forced air) for fruit flies, so the fruit are transferred to the treatment facility after inspection. On arrival at the treatment facility, the crates are again weighed to ensure only previously cleared fruit is on the export pathway.

After treatment, the breadfruit are allowed to cool (Figure 6) in a secure pest-proof area within the facility and then packed for export. They may be packed in single layer standard commercial cartons with partitions to prevent movement of fruit. Alternatively, the fruit may be individually wrapped in paper to prevent the fruit being damaged in transit, before being placed in cartons without partitions (Figure 7).

Importers typically prefer cartons to contain fruit of similar size (usually between 10 to 17 centimetres diameter), so graded fruit may be packed accordingly. For breadfruit exported from Fiji, each carton contains around 10 to 12 kilograms of fruit, depending on the fruit size and importer preference. Larger cartons containing up to 20 kilograms were observed in Tonga. Ideally, the packed breadfruit cartons are loaded directly into an airfreight container, which is then transferred to the airport for export the same day. The breadfruit are not refrigerated during transit, but if the consignment is not being exported soon after packing, the cartons may be held in a cool room at around 12 to 15 °C until ready for export (NWC 2005).

Figure 6 Breadfruit ready for packing after removal from the HTFA chamber, Nadi, Fiji

Figure 7 Individually wrapped breadfruit packed in a carton for export, Nadi, Fiji

3.6 Export capability

3.6.1 Export statistics

Although commonly grown as backyard trees across Fiji, Samoa and Tonga, commercial breadfruit production is still a developing industry. Access to international markets is currently very limited and export volumes are variable. In recent years Fiji has only exported around 10 tonnes of breadfruit per year, but there is the capacity to significantly increase this given the establishment of new orchards and introduction of different varieties to extend the production season.

While Samoa and Tonga have previously exported fresh breadfruit to New Zealand, the current export volumes are negligible, with exporters preferring to export frozen breadfruit, which has access to many more markets, including Australia.

3.6.2 Export season

There is considerable variability in the availability of breadfruit. The breadfruit season in Fiji runs from October to May (NWC 2005), which is when most exports occur. Different varieties are being trialled in Fiji to extend the season. In Samoa, some breadfruit may be available for most of the year. Supply is typically lowest in April and May, but this is not always the case, depending on seasonal conditions (MAF 2007). Tonga’s breadfruit season is usually December to April.

4 Pest risk assessments for quarantine pests

A total of eleven quarantine pests (Table 4.1) associated with the fresh breadfruit import pathway from Fiji, Samoa and Tonga were identified in the pest categorisation process (Appendix A). This chapter assesses the likelihood of the entry (importation and distribution), establishment and spread of these species, and the economic (including environmental), consequences these species may cause if they were to enter, establish and spread in Australia.

Six pests identified in the assessment have been recorded in some regions of Australia, and due to interstate quarantine regulations and enforcement, are considered pests of regional concern. The acronym for the state or territory for which the regional pest status is considered, such as 'WA' (Western Australia), is used to identify these organisms.

Most of the identified quarantine pests and all pest groups considered here have been assessed previously by the department. Therefore, the outcomes of the previous assessments have been extended to include these pests, unless new information is available suggesting that the risk would be different. The acronym 'EP' (existing policy) is used to identify species assessed previously and for which import policy already exists. The adoption from previous assessments are outlined in Section 2.2.6.

Table 4.1 Quarantine pests for breadfruit from Fiji, Samoa and Tonga

Pest	Common name	Countries pest is present
Fruit flies [Diptera: Tephritidae]		
Bactrocera facialis	Fruit fly	Tonga
Bactrocera passiflorae	Fijian fruit fly	Fiji
Bactrocera xanthodes	Pacific fruit fly	Fiji, Samoa, Tonga
Armoured scales [Hemiptera: Diaspididae]		
Chrysomphalus dictyospermi (EP, WA)	Spanish red scale	Fiji, Samoa, Tonga
Hemiberlesia cyanophylli (EP, WA)	Cyanophyllum scale	Fiji, Samoa, Tonga
Hemiberlesia palmae (WA)	Palm scale	Fiji, Samoa, Tonga
Pseudaulacaspis pentagona (EP, WA)	White peach scale	Fiji, Samoa, Tonga
Mealybugs [Hemiptera: Pseudococcidae]		
Dysmicoccus neobrevipes (EP)	Grey pineapple mealybug	Samoa
Dysmicoccus nesophilus	Mealybug	Fiji, Samoa, Tonga
Planococcus minor (EP, WA)	Pacific mealybug	Fiji, Samoa, Tonga
Pseudococcus cryptus (EP, WA)	Cryptic mealybug	Samoa

EP: Species has been assessed previously and import policy already exists. **WA:** Pest of quarantine concern for Western Australia.

4.1 Fruit flies

Bactrocera facialis, *Bactrocera passiflorae* and *Bactrocera xanthodes*

Bactrocera facialis, *Bactrocera passiflorae* and *Bactrocera xanthodes* are fruit flies belonging to the Tephritidae family. They have been grouped together in this assessment because of their related biology and taxonomy, and are predicted to pose a similar risk, and to require similar mitigation measures.

Bactrocera facialis, *Bactrocera passiflorae* and *Bactrocera xanthodes* are three important fruit fly pests in the South Pacific region. Fruit flies are amongst the most serious pests of horticultural production and trade, as feeding by larvae causes destruction of fruits and vegetables (Allwood & Leblanc 1997).

Bactrocera passiflorae, the Fiji fruit fly, is endemic to the Fiji Islands, but is also present in Niue and Wallis and Futuna (Leblanc et al. 2012). An undescribed 'pale form' of Fijian fruit fly, *Bactrocera passiflorae* (sp. nr.), has been reported in Fiji, Tokelau, Tuvalu, and the isolated Niuatoputapu and Niuaf'ou islands in the far north of the Tonga archipelago (Heimoana et al. 1997; Litsinger et al. 1991). The taxonomic status of this fly has not been resolved, and it has yet to be designated or named as a new species (Leblanc et al. 2012). This pale form has not been recorded as a pest of breadfruit, although further research is required to examine this.

The department assessed *Bactrocera passiflorae* and *Bactrocera xanthodes* historically, prior to the current risk assessment process, and determined they were significant quarantine pests. There are existing risk management measures for *Bactrocera passiflorae* and *Bactrocera xanthodes* applied to fresh papaya fruit imported from Fiji (Biosecurity Australia 2002).

The risk scenario of concern for these fruit flies is the presence of developing larvae within imported fresh breadfruit.

4.1.1 Likelihood of entry

The likelihood of entry is considered in two parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that fruit flies will arrive in Australia with breadfruit imported from Fiji, Samoa and Tonga is assessed as High.

The following information provides supporting evidence for this assessment.

- Breadfruit is reported as a host of *Bactrocera facialis*, *B. passiflorae* and *B. xanthodes* (Hinckley 1965b; White & Elson-Harris 1994). Fruit harvested at the 'mature green' stage (slightly less than fully mature) have low susceptibility to fruit fly attack (MAF 2007; Ragone 2011), but the possibility of oviposition cannot be excluded.
- *Bactrocera xanthodes* is present in Fiji, Samoa and Tonga (Leblanc et al. 2012). *Bactrocera passiflorae* is present in Fiji (Leblanc et al. 2012). *Bactrocera facialis* is present in Tonga (Litsinger et al. 1991).
- Adult fruit flies may be present in orchards all year round, provided hosts are available and the temperature does not drop too low (Waterhouse 1993). Adults would not remain on

fruit during harvest or pre-export handling, so are unlikely to be present in imported consignments of breadfruit.

- Adult females lay eggs under the surface of host fruit, particularly on ripe or ripening fruit (Christenson & Foote 1960). Fruit flies often select damaged sites on the fruit surface in which to oviposit, such as cracks, bird and insect damage, and particularly oviposition holes made by other fruit flies (Bateman 1972).
- *Bactrocera passiflorae* eggs have been reported to hatch 32 hours after oviposition under typical Fijian summer conditions of 25 to 29 °C (Simmonds 1935, cited in Leweniqila et al. 1997a). The egg stage may have a longer duration under cooler conditions, with hatching occurring after 36 to 48 hours in papaya and eggplant fruit kept at 24.5 °C (Leweniqila et al. 1997a). *Bactrocera xanthodes* eggs have been reported to hatch after 44 to 52 hours at 26 °C (Clare 1997).
- Larvae feed within the fruit before emerging to pupate, and could potentially be present in fruit that is packed for export. The duration of the larval stages will vary according to seasonal conditions, or with cool storage of the fruit after harvest. For *Bactrocera passiflorae* reared at 24.5 °C, the third instar larvae emerge from the fruit to pupate around 8 to 10 days after oviposition (Leweniqila et al. 1997a), while *Bactrocera xanthodes* larvae emerge after around 8 to 12 days at 26 °C (Clare 1997). Fruit fly larvae could therefore potentially be present in imported breadfruit.
- Infested fruit may not be detected during sorting, packing and inspection procedures, particularly if oviposition occurs just before the fruit is harvested. Following oviposition some necrosis may develop around puncture marks, followed by decomposition of the fruit (CABI 2019), but this may not be apparent for some time on breadfruit with a rough surface.

The presence of fruit flies in breadfruit production areas of Fiji, Samoa and Tonga, their association with mature breadfruit, the internal feeding behaviour of larvae and the difficulty in detecting larvae in infested fruit support a likelihood estimate for importation of High.

Likelihood of distribution

The likelihood that fruit flies will be distributed within Australia in a viable state as a result of the processing, sale or disposal of breadfruit from Fiji, Samoa or Tonga, and subsequently transfer to a susceptible host is assessed as High.

The following information provides supporting evidence for this assessment.

- Breadfruit is not widely consumed in Australia, and is predominantly favoured by Pacific Islander and Asian communities. As a result, distribution of breadfruit will mainly be to larger population centres where there is demand for the fruit. The short shelf life of fresh breadfruit may also limit its distribution beyond the major cities.
- Infested fruit will usually decay as maggots feed on the tissue, although the large size of the breadfruit and firmness of the flesh means that damage may not be readily apparent. Decaying fruit would typically be discarded when detected. Infested fruit discarded via municipal waste systems are likely to be mixed with other waste material and buried at dump sites. Waste at municipal tips is regularly covered over, and pupae amongst waste are likely to be buried during that period. It is considered there is only a very low likelihood that

adults would emerge from waste buried in municipal waste systems and be able to seek out a suitable host.

- Fruit fly larval stages are relatively brief, for example around 8 to 12 days after oviposition for *Bactrocera xanthodes* (Clare 1997), so fruit flies may be able to complete their larval stage development if the fruit remains relatively intact for a few days after importation.
- Some third-instar larvae may emerge from fruit during transit, or elsewhere in the supply chain, or from discarded fruit. The larvae are capable of jumping along the ground for short distances to find a suitable pupation site (White & Elson-Harris 1994). Those that can find a sheltered location (for example, in soil, leaf litter or the bottom of a fruit carton) in which to undergo pupation may be able to survive and complete development.
- The *Bactrocera xanthodes* pupation phase takes around 11 to 17 days at 26 °C (Clare 1997), while for *Bactrocera passiflorae* it can be around 9.5 to 12 days at 24.5 °C (Leweniqila et al. 1997a).
- Once adults emerge from pupation they will seek out a suitable host plant. Adult fruit flies are capable of flying significant distances within a few days (Christenson & Foote 1960). Other species such as *Bactrocera dorsalis* have been reported as travelling 6 to 24 kilometres from the point of release, and can travel 14 kilometres across open seas between islands (Christenson & Foote 1960).
- *Bactrocera facialis*, *Bactrocera passiflorae* and *Bactrocera xanthodes* are polyphagous species, and suitable host plants are readily available in many parts of Australia. *Bactrocera facialis* hosts include avocado, capsicum, chilli, citrus, mango, peach and tomato. *Bactrocera passiflorae* hosts include avocado, some varieties of chilli, grapefruit, kumquat, lemon, mandarin, mango, orange, papaya and pomelo. *Bactrocera xanthodes* hosts include avocado, kumquat, mandarin, mango, orange, papaya, passionfruit, pomelo, tomato and watermelon (Leblanc et al. 2012).
- Even if distribution of the breadfruit was largely confined to the major cities, there would still be suitable host fruit available in many backyard gardens, parks and other urban environments at various times of year, depending on the specific location.

The presence of larvae in the imported breadfruit would potentially allow wide distribution of fruit flies to wherever the fruit may be transported on arrival in Australia, and the mobility of the larvae after leaving the fruit would allow them to seek out suitable pupation sites to complete development. After adult emergence, suitable host plants would likely be available in many localities. These factors support a likelihood estimate for distribution of High.

Overall likelihood of entry

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules shown in Table 2.2.

The likelihood that fruit flies will enter Australia as a result of importation of breadfruit from Fiji, Samoa or Tonga and be distributed in a viable state to susceptible hosts is assessed as High.

4.1.2 Likelihood of establishment

The likelihood that fruit flies will establish within Australia, based on comparison of factors in the source and destination areas that affect pest survival and reproduction, is assessed as High.

The following information provides supporting evidence for this assessment.

- *Bactrocera xanthodes* has a history of establishing in new locations following accidental introductions. It has previously become established in the Cook Islands (early 1970s) (Purea, Putoa & Munro 1997), Nauru (first detected in 1992) (Allwood et al. 2002) and French Polynesia (1998) (Leblanc, Vargas & Putoa 2013).
- Adult fruit flies require a suitable protein source to attain sexual maturity, which is commonly obtained from bacteria (White & Elson-Harris 1994), fungi, or even bird faeces (Christenson & Foote 1960) on plant surfaces. They also require access to water every few days for survival, which may be obtained from dew or rain drops (Christenson & Foote 1960).
- *Bactrocera xanthodes* adult females start mating and ovipositing around 12 days after emerging from pupation at 26 °C (Clare 1997). However, the pre-oviposition period may be longer under cool temperature conditions (Christenson & Foote 1960), increasing the chance of predation or other mortality before reproducing.
- Mating is necessary for the production of viable eggs (Waterhouse 1993). Sexually mature adults of both sexes would need to be present within reasonable proximity to enable them to locate each other for mating. As *Bactrocera* spp. typically lay multiple eggs in a single fruit, it is possible that both adult male and female flies could be present in the vicinity at the same time originating from an infested imported breadfruit.
- Odours from suitable host plants play an important role in attracting fruit flies (White & Elson-Harris 1994). Pheromones also play a role in assisting flies to locate each other for mating. Adult males release volatile pheromones from a rectal sac to attract females (Symonds, Moussalli & Elgar 2009).
- Adult fruit flies can survive for some time in the environment. Information on the longevity of *Bactrocera passiflorae* and *Bactrocera xanthodes* is not available, but other *Bactrocera* species typically live for one to three months. *Bactrocera dorsalis* and *Zeugodacus cucurbitae* (formerly *Bactrocera* (*Zeugodacus*) *cucurbitae* and *Dacus* (*Zeugodacus*) *cucurbitae*) adults have been reported to survive for more than a year in cool conditions (Christenson & Foote 1960). This longevity may increase the potential of finding a mating partner if there were multiple fruit fly introductions via separate consignments at different times.
- Host plants are present in many parts of Australia. Fruit suitable for oviposition would be readily available for much of the year. However, establishment is only likely to occur in regions with suitable climatic conditions. Previous accidental introductions of *Bactrocera passiflorae* into New Zealand did not result in establishment of a population (White & Elson-Harris 1994), possibly because the conditions were unfavourable.

The potential for both male and female fruit flies to be imported together in the same fruit increases the likelihood of successful mating occurring. Given the wide host ranges of these pests, it is likely that suitable ripe fruit would be available for oviposition for much of the year. These factors support a likelihood estimate for establishment of High.

4.1.3 Likelihood of spread

The likelihood that fruit flies will spread within Australia, based on a comparison of factors in the source and destination areas that can affect the geographic distribution of the pests, is assessed as High.

The following information provides supporting evidence for this assessment.

- Fruit flies can fly considerable distances, so a gradual natural spread would be anticipated in the absence of any control measures.
- Spread over longer distances may occur more rapidly via movement of infested fruit to other regions. Fruit fly hosts include many commonly traded fruit and vegetables.
- Suitable host plants are present in many parts of Australia. *Bactrocera facialis*, *Bactrocera passiflorae* and *Bactrocera xanthodes* could potentially spread in northern Australia, from northern New South Wales to the north-west of Western Australia, particularly in fruit-growing areas.
- Although the specific climatic requirements of these species are not well known, spread to regions in southern Australia and establishment of permanent populations may be limited by climatic preferences. These flies, however, may be capable of thriving in a broader range of climatic zones than the current Pacific Islands distribution indicates.
- Competition from other fruit fly species in Australia could potentially curtail spread. Competitive exclusion is known to occur between species of *Bactrocera*. For example, a population decline in *Bactrocera curvipennis* in New Caledonia was attributed to the introduction of the dominant Queensland fruit fly (*Bactrocera tryoni*) (Amice & Sales 1997). *Bactrocera tryoni* is widespread in eastern Australia, but its potential for competitive impacts on *Bactrocera facialis*, *Bactrocera passiflorae* and *Bactrocera xanthodes* populations have not been studied.
- A number of opiine wasp (Braconidae) parasitoids of *Bactrocera facialis*, *Bactrocera passiflorae* and *Bactrocera xanthodes* are present in Australia, including *Fopius arisanus*, *Diachasmimorpha tryoni*, *Psyttalia concolor* and *Psyttalia fijiensis* (Waterhouse 1993). These parasitoids oviposit into fruit fly eggs (*Fopius arisanus*) or larvae (*Diachasmimorpha tryoni*, *Psyttalia* spp.), completing development in, and emerging from, the puparium, killing the fruit flies (Waterhouse 1993).
- Parasitoids may reduce the abundance of adult fruit flies (Waterhouse 1993), but may be inadequate to prevent economic damage or further spread. In Fiji *Fopius arisanus* has had only limited success against *Bactrocera passiflorae*, which commonly oviposits in fruit on the ground, because the parasitoid rarely searches fallen fruit for fruit fly eggs (Waterhouse 1993).

Many parts of northern Australia may have a suitable climate and host plants for these fruit flies, which have the ability to fly considerable distances or spread via movement of infested fruit. These factors support a likelihood estimate for spread of High.

4.1.4 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that fruit flies will enter Australia as a result of trade in breadfruit from Fiji, Samoa or Tonga, be distributed in a viable state to a susceptible host, establish in Australia, and subsequently spread within Australia is assessed as High.

4.1.5 Consequences

The potential consequences of the establishment of fruit flies in Australia have been estimated according to the methods described in Table 2.3.

Based on the decision rules described in Table 2.4, that is, where the potential consequences of a pest with respect to a single criteria having an impact of 'F', the overall consequences are estimated to be High.

Criterion	Estimate and rationale
Direct	
Plant life or health	E— significant at the region level These fruit flies are potentially serious pests of a number of fruit and vegetable crops, causing destruction of host fruits and vegetables. Infested fruit may drop prematurely (Allwood and Leblanc 1997). The main crops affected include avocado, mango, papaya, guava, kumquat, lemon, pomelo, grapefruit and tomato (Leblanc, Tora Vueti & Allwood 2013). Potential impacts on native plant life, such as fruiting rainforest trees, are difficult to estimate. *Bactrocera xanthodes* is not associated with forest habitats in Fiji, and has a preference for orchard habitats (Leweniqila et al. 1997b). *Bactrocera facialis* is present in both orchards and forest habitat in Tonga (Leweniqila et al. 1997b). *Bactrocera passiflorae* is present in both orchard and forest habitats in Fiji, although the abundance in the forest is seasonal, coinciding with the fruiting of its preferred host, *Amaroria soulameoides* (Leweniqila et al. 1997b). This plant is not known to be present in Australia, but related species from the Simaroubaceae family could be potential hosts.
Other aspects of the environment	A— indiscernible at the local level Direct impacts are limited to effects on plant health. No other direct impacts on the environment associated with these fruit flies have been reported.
Indirect	
Eradication, control	F— major significance at the region level Significant resources would be required to undertake an eradication program if an incursion eventuated. The eradication program for papaya fruit fly (*Bactrocera dorsalis* (under the name of *Bactrocera papayae*)) in North Queensland in the late 1990s cost $34 million, as well as an estimated $100 million in direct and indirect costs to growers from associated quarantine restrictions and treatments (Cantrell, Chadwick & Cahill 2002).
Domestic trade	E— significant at the region level An incursion of these fruit flies is likely to disrupt domestic trade, as barriers to prohibit or regulate movement of horticultural produce would be implemented and enforced.
International trade	E— significant at the region level An incursion of these fruit flies would be likely to adversely affect access to international markets for a range of horticultural produce. Trade to existing markets may cease immediately, and additional phytosanitary requirements would be likely to be

	imposed by other countries. Restoring market access could take considerable time and resources, resulting in significant losses to some export-oriented growers.
Environmental and non-commercial	A— indiscernible at the local level The potential impacts to plant health are unlikely to result in discernible changes to plant communities, ecological processes, the natural environment or human recreational uses.

4.1.6 Unrestricted risk estimate

Unrestricted risk is the result of combining the likelihoods of entry, establishment and spread with the assessed outcome of overall consequences, using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for fruit flies	
Overall likelihood of entry, establishment and spread	High
Consequences	High
Unrestricted risk	High

As indicated, the unrestricted risk estimate for fruit flies has been assessed as High, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for these pests.

4.2 Armoured scales

***Chrysomphalus dictyospermi* (EP, WA), *Hemiberlesia cyanophylli* (EP, WA), *Hemiberlesia palmae* (WA), *Pseudaulacaspis pentagona* (EP, WA)**

Chrysomphalus dictyospermi, *Hemiberlesia cyanophylli*, *Hemiberlesia palmae* and *Pseudaulacaspis pentagona* are not present in Western Australia and are pests of regional concern for that state.

The biological characteristics and behaviours of these species on the importation pathway are considered sufficiently similar to justify combining them in a single assessment. In this assessment, the term 'armoured scales' is used to refer to these four species unless otherwise specified.

Chrysomphalus dictyospermi was previously assessed in the development of policy for sweet oranges from Italy (Biosecurity Australia 2005). *Hemiberlesia cyanophylli* was previously assessed (as *Abgrallaspis cyanophylli*) for mangoes from India (Biosecurity Australia 2008). *Pseudaulacaspis pentagona* was previously assessed in the policy for capsicums from Korea (Biosecurity Australia 2009).

The current assessment of these armoured scales builds on the previous assessments indicated above. However, there are differences in horticultural practices, climatic conditions and pest prevalence among the current (breadfruit) and previously assessed commodity pathways (mangoes, oranges and capsicums). These differences make it necessary to reassess the likelihood that armoured scales will be imported into Western Australia with fresh breadfruit from Fiji, Samoa and Tonga.

The risk scenario of concern for armoured scales is the presence of eggs, nymphs or adult females on imported breadfruit, and of these pests subsequently entering Western Australia.

After importation, breadfruit from Fiji, Samoa and Tonga may be distributed throughout Australia for sale in a similar way to oranges from Italy, mangoes from Taiwan and capsicums from Korea. Retail distribution of the breadfruit may not be as geographically spread as for these other commodities, as fresh breadfruit has a relatively short shelf life, and demand will largely be from the Pacific Islander and Asian communities located in major cities. Nevertheless, given the wide range of suitable host plants available in many urban areas, opportunities for armoured scales to disperse from the breadfruit and locate a suitable host plant are likely to be similar to those previously assessed for mangoes, oranges and capsicums. Therefore, the likelihood of distribution of these armoured scales on breadfruit would be comparable to that assessed previously.

The likelihoods of establishment and spread of armoured scales in Australia, and the consequences they may cause, will be comparable to those previously assessed for oranges from Italy, mangoes from Taiwan and capsicums from Korea. These likelihoods relate specifically to events that occur subsequent to arrival in Australia, and are largely independent of the importation pathway. Accordingly, there is no need to reassess these components, and estimates of the risk ratings for distribution, establishment, spread and consequences will be adopted from existing policy for these species.

4.2.1 Likelihood of entry

The likelihood of entry is considered in two parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that armoured scales will arrive in Western Australia with the importation of breadfruit from Fiji, Samoa and Tonga is assessed as High.

The following information provides supporting evidence for this assessment.

- *Chrysomphalus dictyospermi*, *Hemiberlesia cyanophylli*, *Hemiberlesia palmae* and *Pseudaulacaspis pentagona* are all present in Fiji, Samoa and Tonga (García Morales et al. 2019; Stout 1982; Williams & Watson 1988a). Breadfruit is reported as a host for these species (Williams & Watson 1988a).
- Armoured scales may be present on breadfruit, although *Chrysomphalus dictyospermi, Hemiberlesia cyanophylli* and *Hemiberlesia palmae* have a preference for the leaves of host plants (Miller & Davidson 2005; Watson 2017; Williams & Watson 1988a). *Pseudaulacaspis pentagona* occurs on the fruit, leaves and bark of hosts (Williams & Watson 1988a).
- Armoured scales are small and may be difficult to detect on the breadfruit surface, particularly if they are only present in small numbers. The adult female *Hemiberlesia cyanophylli* adult females grow up to 2.25 millimetres in length (Martin Kessing & Mau 2007a).
- Adult males and the immature stages are smaller than the adult females. The adult male of *Pseudaulacaspis pentagona* is only 1.25 millimetres in length (Waterhouse & Norris 1987).
- The first instar crawlers and adult males are active, and these may be dislodged at harvest and during pre-export handling, so are less likely to be present. The other life stages are sessile under the protective scale. Female nymphs lose their legs after the first moult, and are unable to move. Armoured scales that are affixed to fruit are unlikely to be dislodged by pre-export handling (including washing) of fruit.
- Adult females lay eggs under the scale cover, and these eggs are likely to remain intact during pre-export handling and transit. The incubation period for eggs varies amongst scale species. Under warm conditions, hatching of *Pseudaulacaspis pentagona* eggs takes around four to five days (Waterhouse & Norris 1987). Some armoured scales are ovoviviparous, delivering live nymphs that hatched from eggs while still inside the adult female. *Chrysomphalus dictyospermi* eggs may hatch within a day of oviposition, or crawlers may be laid directly without an egg stage (Miller & Davidson 2005).
- Adult male armoured scales are short-lived, and do not feed. *Pseudaulacaspis pentagona* adult males do not survive for more than 24 hours (Waterhouse & Norris 1987). They have wings and actively move about in search of females, so are unlikely to remain on fruit after harvest. However, they may still be present on imported breadfruit if they emerge from pupation during transit, but are likely to leave the pathway at the earliest opportunity.

The presence of armoured scales in Fiji, Samoa and Tonga, and their association with breadfruit, their small size and cryptic colouring, and the tendency for most life stages to remain affixed to fruit after harvest and during transit, support a likelihood estimate for importation of High.

Likelihood of distribution

As indicated, the likelihood of distribution for armoured scales is based on previous assessments of *Chrysomphalus dictyospermi*, *Hemiberlesia cyanophylli* and *Pseudaulacaspis pentagona*. The ratings of previous assessments were Low.

The biology and host association of *Hemiberlesia palmae* are similar to *Chrysomphalus dictyospermi*, *Hemiberlesia cyanophylli* and *Pseudaulacaspis pentagona*. Taking this into consideration, the likelihood of distribution for *Hemiberlesia palmae* is also estimated to be Low.

Overall likelihood of entry (importation x distribution)

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules shown in Table 2.2.

The likelihood that armoured scales will enter Western Australia as a result of trade in breadfruit from Fiji, Samoa or Tonga, and be distributed in a viable state to susceptible hosts is assessed as Low.

4.2.2 Likelihood of establishment and spread

As indicated, the likelihood of establishment and spread for armoured scales is being based on previous assessments of *Chrysomphalus dictyospermi*, *Hemiberlesia cyanophylli* and *Pseudaulacaspis pentagona*. The ratings of previous assessments were:

Likelihood of establishment:	High
Likelihood of spread:	Moderate

These ratings are also considered to also be applicable to *Hemiberlesia palmae*, which has similar biology, climatic preferences and host availability to *Chrysomphalus dictyospermi*, *Hemiberlesia cyanophylli* and *Pseudaulacaspis pentagona*.

4.2.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that armoured scales will enter Western Australia as a result of trade in breadfruit from Fiji, Samoa or Tonga, be distributed in a viable state to susceptible hosts, establish in Western Australia, and subsequently spread within Western Australia is assessed as Low.

4.2.4 Consequences

As indicated, the estimate of potential consequences is based on previous assessments. The potential consequences of the establishment of armoured scales in Western Australia have been estimated in previous policies to be Low.

The impacts of *Hemiberlesia palmae* are not reported to be significantly different to *Chrysomphalus dictyospermi*, *Hemiberlesia cyanophylli* and *Pseudaulacaspis pentagona*. Taking this into consideration, the consequences for *Hemiberlesia palmae* are also estimated to be Low.

4.2.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the likelihoods of entry, establishment and spread with the assessed outcome of overall consequences. Likelihoods and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for armoured scales	
Overall likelihood of entry, establishment and spread	Low
Consequences	Low
Unrestricted risk	Very low

As indicated, the unrestricted risk estimate for armoured scales has been assessed as Very low, which achieves ALOP for Australia. Therefore, specific risk management measures are not required for these pests.

4.3 Mealybugs

***Dysmicoccus neobrevipes* (EP), *Dysmicoccus nesophilus*, *Planococcus minor* (EP, WA), *Pseudococcus cryptus* (EP, WA)**

Planococcus minor and *Pseudococcus cryptus* are not present in Western Australia and are pests of regional concern for that state.

Dysmicoccus neobrevipes has previously been assessed in the development of policies for mangosteens from Thailand (DAFF 2004) and pineapples from Malaysia (DAFF 2012). *Planococcus minor* was previously assessed for pineapples from Malaysia (DAFF 2012) and island cabbage from the Pacific (Cook Islands, Fiji, Samoa, Tonga and Vanuatu) (DAFF 2013). *Pseudococcus cryptus* was previously assessed for mangoes from Taiwan (Biosecurity Australia 2006). In previous assessments, the unrestricted risk for mealybugs was found to be Low, with pre-export phytosanitary inspection required to check for their presence, and appropriate remedial action if they are detected. *Dysmicoccus nesophilus* has not previously been assessed.

The current assessment of these mealybug species builds on the previous policies indicated above. However, as these policies are for other commodities from different countries, there are differences in horticultural practices, climatic conditions and pest prevalence that make it necessary to reassess the likelihood that mealybugs will be imported with fresh breadfruit from Fiji, Samoa and Tonga.

The risk scenario of concern for mealybugs is the presence of eggs, nymphs or adult females on imported breadfruit.

After importation, breadfruit from Fiji, Samoa and Tonga will be distributed throughout Australia for retail sale in a similar way to mangoes, mangosteens and pineapples. Retail distribution of the breadfruit may not be as geographically spread as for these other commodities, as fresh breadfruit has a relatively short shelf life, and demand will largely be from the Pacific Islander and Asian communities located in major cities. Nevertheless, given the wide range of suitable host plants available in many urban areas, opportunities for mealybugs to disperse from breadfruit and locate a suitable host plant are likely to be similar to those previously assessed for mangoes, mangosteens and pineapples. Therefore, the likelihood of distribution for mealybugs on breadfruit would be comparable to that assessed previously.

The likelihoods of establishment and spread of these mealybugs in Australia and the consequences they may cause, are comparable for any commodity on which these species are imported, as these likelihoods relate specifically to events that occur in Australia and are largely independent of the importation pathway. Accordingly, there is no need to reassess these components, and the previous estimates of risk ratings for establishment, spread and consequences will be adopted from existing policies for these species.

4.3.1 Likelihood of entry

The likelihood of entry is considered in two parts, the likelihood of importation and the likelihood of distribution, which consider pre-border and post-border issues, respectively.

Likelihood of importation

The likelihood that mealybugs will arrive in Australia with the importation of breadfruit from Fiji, Samoa and Tonga is assessed as High.

The following information provides supporting evidence for this assessment.

- The identified mealybugs are present in one or more of the countries being assessed (García Morales et al. 2019; Williams & Watson 1988b). *Dysmicoccus nesophilus* and *Planococcus minor* are present in Fiji, Samoa and Tonga (Cox 1989; Williams & Watson 1988b). *Dysmicoccus neobrevipes* and *Pseudococcus cryptus* are present in Samoa (Williams & Watson 1988b).
- Breadfruit is reported as a host of the identified mealybugs (Cox 1989; Williams & Watson 1988b), and these species are associated with the fruit of hosts (Martin Kessing & Mau 2007a; Venette & Davis 2004), so could be imported on breadfruit.
- *Dysmicoccus nesophilus* has previously been intercepted in New Zealand on fresh breadfruit imported from South Pacific countries (Williams & Watson 1988b).
- *Dysmicoccus neobrevipes* is commonly intercepted on tropical fruits from southern Asia in international trade (García Morales et al. 2019).
- *Planococcus minor* is commonly intercepted on plant material entering the United States of America, with around 240 interceptions annually (Venette & Davis 2004). However, these interceptions are primarily associated with plant material carried by international airline passengers (75 per cent) rather than in cargo (16 per cent) (Venette & Davis 2004).
- *Planococcus minor* is likely to have spread throughout the Pacific region, and been introduced to eastern Australia, by human activities (Cox 1989; Williams & Watson 1988b).
- Mealybugs are small and may be difficult to detect. *Pseudococcus cryptus* adult females grow up to 3.15 millimetres in length (Williams & Watson 1988b). *Planococcus minor* adult females are around 1.3 to 3.2 millimetres in length, and are covered with white powdery wax (Cox 1989).
- *Dysmicoccus neobrevipes* is broadly oval in shape, and is around 1.5 millimetres in length (Martin Kessing & Mau 2007b), but can grow up to 3.5 millimetres (Williams & Watson 1988b). Its dorsal surface is heavily coated with tiny tufts of white mealy wax. Short filaments of wax extend from around the margin of the entire body (Martin Kessing & Mau 2007b).
- Nymphal instars, pre-pupal and pupal stages, and adult males are smaller than adult females, and would be more difficult to detect on breadfruit.
- Mealybug eggs are tiny, but they may be laid in groups or inside an ovisac, which would be more readily visible.
- *Planococcus minor* eggs are laid in waxy ovisacs that may be found beneath or beside females on leaf surfaces (Stocks & Roda 2011).
- *Pseudococcus cryptus* is oviparous (egg-laying), with the female typically laying eggs in groups of 30 to 50, although ovoviviparous behaviour (eggs hatch within the female) is also reported (Kim, Song & Kim 2008).
- *Dysmicoccus neobrevipes* is ovoviviparous, giving birth to live nymphs (Martin Kessing & Mau 2007b).

The presence of these mealybugs in Fiji, Samoa and Tonga, their association with breadfruit, and the history of interceptions in international trade support a likelihood estimate for importation of High.

Likelihood of distribution

As indicated, the likelihood of distribution for mealybugs is based on previous assessments of *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus cryptus*. The ratings of previous assessments were Moderate.

The biology and host association of *Dysmicoccus nesophilus* are similar to *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus cryptus*. Taking this into consideration, the likelihood of distribution of *Dysmicoccus nesophilus* is also estimated to be Moderate.

Overall likelihood of entry (importation x distribution)

The overall likelihood of entry is determined by combining the likelihood of importation with the likelihood of distribution using the matrix of rules shown in Table 2.2.

The likelihood that mealybugs will enter Australia as a result of trade in breadfruit from Fiji, Samoa or Tonga, and be distributed in a viable state to a susceptible host is Moderate.

4.3.2 Likelihood of establishment and spread

As indicated, the likelihood of establishment and spread for mealybugs is being based on previous assessments of *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus cryptus*. The ratings of previous assessments were:

Likelihood of establishment:	High
Likelihood of spread:	High

These ratings are considered to also be applicable to *Dysmicoccus nesophilus*, which has similar biology, climatic preferences and host availability to *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus cryptus*.

4.3.3 Overall likelihood of entry, establishment and spread

The overall likelihood of entry, establishment and spread is determined by combining the likelihoods of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that mealybugs will enter Australia as a result of trade in breadfruit from Fiji, Samoa or Tonga, be distributed in a viable state to susceptible hosts, establish in Australia, and subsequently spread within Australia is assessed as Moderate.

4.3.4 Consequences

As indicated, the estimate of potential consequences is based on previous assessments of *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus cryptus*. The potential consequences of the establishment of mealybugs in Australia have been estimated in previous policies to be Low.

The impacts of *Dysmicoccus nesophilus* are not reported to be significantly different to *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus cryptus.* Taking this into consideration, the consequences for *Dysmicoccus nesophilus* are also estimated to be Low.

4.3.5 Unrestricted risk estimate

Unrestricted risk is the result of combining the likelihoods of entry, establishment and spread with the assessed outcome of overall consequences. Likelihoods and consequences are combined using the risk estimation matrix shown in Table 2.5.

Unrestricted risk estimate for mealybugs	
Overall likelihood of entry, establishment and spread	Moderate
Consequences	Low
Unrestricted risk	Low

As indicated, the unrestricted risk estimate for mealybugs has been assessed as Low, which does not achieve the ALOP for Australia. Therefore, specific risk management measures are required for these pests.

4.4 Pest risk assessment conclusions

Table 4.2 Summary of unrestricted risk estimates for quarantine pests associated with fresh breadfruit from Fiji, Samoa and Tonga

Pest name	Likelihood of						Consequences	Unrestricted Risk Estimate
	Importation	Distribution	**Entry**	**Establishment**	**Spread**	**[EES]**		
Fruit flies [Diptera: Tephritidae]								
Bactrocera facialis	High	High	High	High	High	High	High	High
Bactrocera passiflorae	High	High	High	High	High	High	High	High
Bactrocera xanthodes	High	High	High	High	High	High	High	High
Armoured scales [Hemiptera: Diaspididae]								
Chrysomphalus dictyospermi [EP, WA]	High	Low	Low	High	Moderate	Low	Low	Very low
Hemiberlesia cyanophylli [EP, WA]	High	Low	Low	High	Moderate	Low	Low	Very low
Hemiberlesia palmae [WA]	High	Low	Low	High	Moderate	Low	Low	Very low
Pseudaulacaspis pentagona [EP, WA]	High	Low	Low	High	Moderate	Low	Low	Very low
Mealybugs [Hemiptera: Pseudococcidae]								
Dysmicoccus neobrevipes [EP]	High	Moderate	Moderate	High	High	Moderate	Low	Low
Dysmicoccus nesophilus	High	Moderate	Moderate	High	High	Moderate	Low	Low
Planococcus minor [EP, WA]	High	Moderate	Moderate	High	High	Moderate	Low	Low
Pseudococcus cryptus [EP, WA]	High	Moderate	Moderate	High	High	Moderate	Low	Low

EP: Species have been assessed previously and import policy already exists. **WA**: Pest of quarantine concern for Western Australia. **EES**: Overall likelihood of entry, establishment and spread. **URE**: Unrestricted risk estimate.

4.5 Summary of the assessment of pests of breadfruit

This section provides an overview of the assessment process for the pests of breadfruit considered in this report. This is summarised in Figure 8.

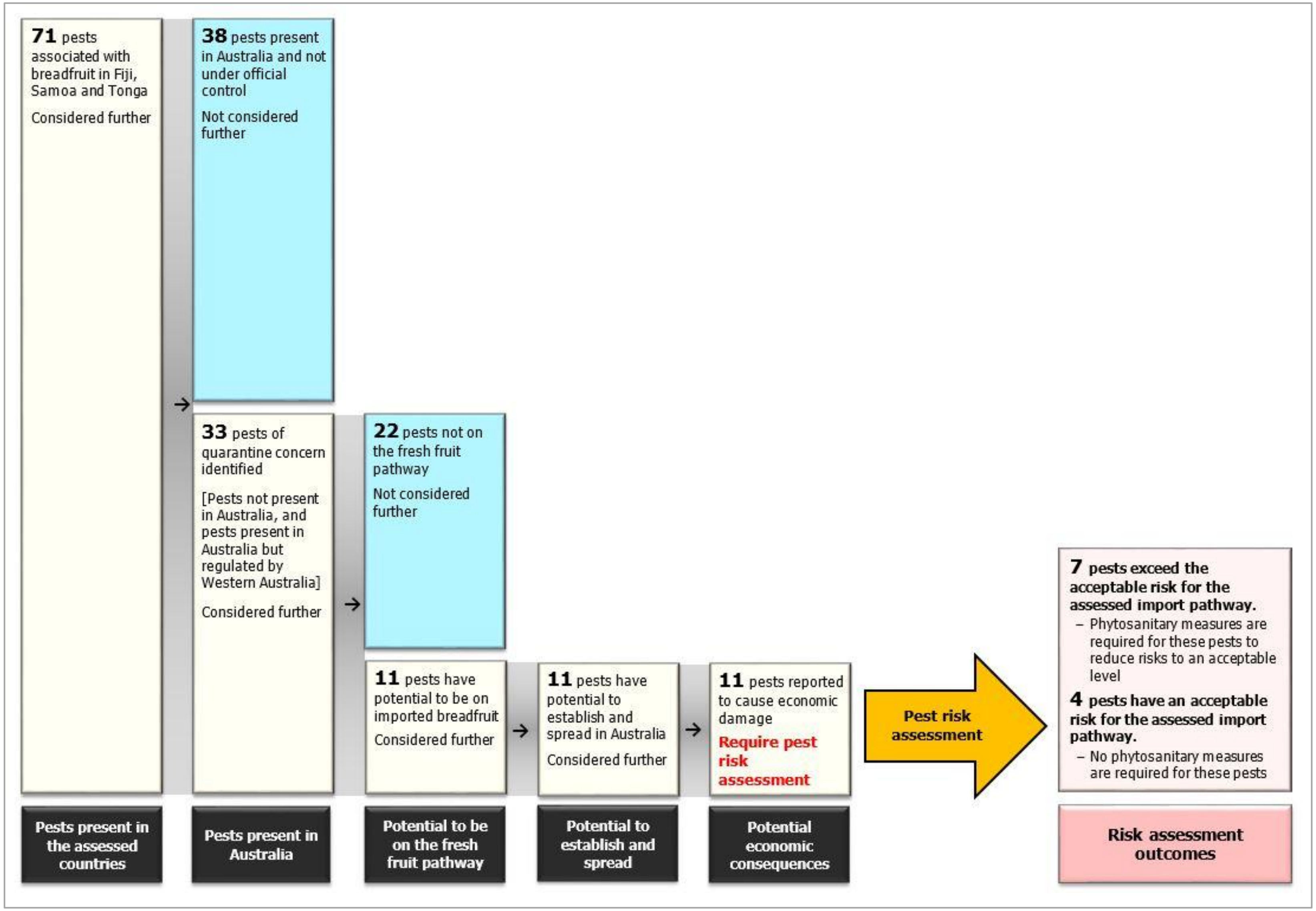
The pest categorisation process (Appendix A) identified 71 pests of breadfruit recorded in Fiji, Samoa and Tonga. Of these 71 pests:

- 38 pests are present in Australia, and not under official control, and therefore were not considered further;
- 22 of the remaining 33 pests were assessed as not having potential to be on the pathway of breadfruit, and therefore were not considered further.

The outcome of the above process left 11 pests that required further consideration, which is pest risk assessment. Pest risk assessments for these 11 pests were completed:

- The estimated risk for four of the pests were assessed as achieving the ALOP for Australia, and thus no specific risk management measures are required for this pathway. These pests are:
  - Spanish red scale (*Chrysomphalus dictyospermi*)
  - Cyanophyllum scale (*Hemiberlesia cyanophylli*)
  - Palm scale (*Hemiberlesia palmae*)
  - White peach scale (*Pseudaulacaspis pentagona*)
- The estimated risk for seven quarantine pests were assessed as not achieving ALOP for Australia and thus specific management measures are required. These pests are:
  - Fruit fly (*Bactrocera facialis*)
  - Fijian fruit fly (*Bactrocera passiflorae*)
  - Pacific fruit fly (*Bactrocera xanthodes*)
  - Grey pineapple mealybug (*Dysmicoccus neobrevipes*)
  - Mealybug (*Dysmicoccus nesophilus*)
  - Pacific mealybug (*Planococcus minor*) and
  - Cryptic mealybug (*Pseudococcus cryptus*).

Figure 8 Summary of pest categorisation and pest risk assessment outcomes



5 Pest risk management

This chapter provides information on the management of quarantine pests identified as having an unrestricted risk level that does not achieve the appropriate level of protection (ALOP) for Australia. The recommended risk management measures for these pests are described in this chapter. This chapter also describes the operational system that is required for the maintenance and verification of the phytosanitary status of breadfruit from Fiji, Samoa and Tonga for export to Australia.

5.1 Pest risk management measures and phytosanitary procedures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests for Australia, where they have been assessed to have an unrestricted risk level that does not achieve the ALOP for Australia. In calculating the unrestricted risk estimate, typical commercial production practices in Fiji, Samoa and Tonga were considered, as were post-harvest procedures (excluding application of phytosanitary treatments required by other markets) and the packing of fruit.

In this chapter, the department recommends risk management measures and phytosanitary procedures to be applied to consignments of breadfruit imported from Fiji, Samoa and Tonga. Finalisation of import conditions may be undertaken with input from the Australian states and territories as appropriate.

5.1.1 Pest risk management for quarantine pests

The pest risk assessments identified pests listed in Table 5.1 as having unrestricted risks that do not achieve the ALOP for Australia. Therefore, risk management measures are required to manage the risks posed by these pests; the recommended measures are listed in Table 5.1.

Table 5.1 Risk management measures recommended for quarantine pests of fresh breadfruit from Fiji, Samoa and Tonga

Pest	Common name	Measures
Bactrocera facialis *Bactrocera passiflorae* *Bactrocera xanthodes*	Fruit fly Fiji fruit fly Pacific fruit fly	High temperature forced air (HTFA) treatment at 47.2 °C for 20 minutes OR Gamma irradiation at 150 gray minimum absorbed dose
Dysmicoccus neobrevipes (EP) *Dysmicoccus nesophilus* *Planococcus minor* (EP, WA) *Pseudococcus cryptus* (EP, WA)	Grey pineapple mealybug Mealybug Pacific mealybug Cryptic mealybug	Pre-export visual inspection and, if found, remedial action **a**

a Remedial action (depending on the location of the inspection) may include treatment of the consignment to ensure that the pest is no longer viable, or withdrawal of the consignment from export to Australia. **EP** Species has been assessed previously and import policy already exists. **WA** Pest of quarantine concern for Western Australia.

5.1.2 Risk management measures for quarantine pests

The risk management measures recommended here are based on existing policies for fresh papaya from Fiji (Biosecurity Australia 2002), mangosteens from Thailand (DAFF 2004), pineapples from Malaysia (DAFF 2012) and mangoes from Taiwan (Biosecurity Australia 2006), which considered risk management measures for the same pests, or pest groups identified in this assessment. The management options proposed in this report for the identified pests are consistent with existing policy.

The high temperature forced air (HTFA) treatment recommended for fruit flies in breadfruit from Fiji, Samoa and Tonga has been successfully used for *Bactrocera passiflorae* and *Bactrocera xanthodes* in fresh papaya imported into Australia from Fiji since 2004. More than 2,200 tonnes of papaya fruit have been imported in this time, and no live fruit flies have been detected.

The final report recommends that when the following risk management measures are applied, the restricted risk for all identified quarantine pests will achieve the appropriate level of protection (ALOP) for Australia. These measures are:

for fruit flies:

- high temperature forced air (HTFA) or irradiation

for mealybugs:

- pre-export visual inspection and, if found, remedial action.

Management for fruit flies

Bactrocera facialis, *Bactrocera passiflorae* and *Bactrocera xanthodes* were assessed to have an unrestricted risk estimate level that does not achieve the ALOP for Australia. Measures are therefore required to manage the biosecurity risk.

A number of phytosanitary treatments are available to eliminate fruit flies, including heat treatments, cold treatments and irradiation (Armstrong 1997). Breadfruit typically suffers from chilling injury when stored at temperatures below about 12°C (NWC 2005), so cold disinfestation treatments are unlikely to be suitable. There are currently no gamma irradiation facilities in Fiji, Samoa or Tonga. Pre-export heat treatments offer the most feasible option for the treatment of breadfruit for export from the Pacific Islands.

To ensure efficacy of any phytosanitary treatment for fruit flies, it is an expectation that in-field control measures (field hygiene practices, bait spraying program, harvesting prior to reaching full maturity) are undertaken as appropriate to reduce fruit fly prevalence.

Recommended measure 1: High temperature forced air treatment

The department recommends a high temperature forced air (HTFA) treatment to reduce the risks associated with *Bactrocera facialis*, *Bactrocera passiflorae* and *Bactrocera xanthodes.*

Fiji, Samoa and Tonga currently export breadfruit to New Zealand under a protocol that requires the core fruit temperature to be raised from ambient to 47.2 °C and maintained for a minimum of 20 minutes (Tiseli 2009).

The use of HTFA treatment as a phytosanitary measure is subject to approval of the offshore HTFA treatment facility by the Department of Agriculture. Exporting countries are required to provide a submission to the department to demonstrate they have processes and procedures for the registration, approval and audit of treatment facilities. The department may request on-site verification of the treatment facilities. Additionally, confirmation of the efficacy of the proposed treatment protocol against *Bactrocera facialis* will be required before HTFA treatment can be approved for Tonga.

Recommended measure 2: Gamma irradiation

The department proposes a gamma irradiation treatment schedule of 150 gray minimum absorbed dose as an effective disinfestation treatment for fruit flies, consistent with ISPM 28 Annex 7: *Irradiation treatment for fruit flies of the family Tephritidae (generic)* (FAO 2017b).

The requirements for using irradiation as a phytosanitary measure are set out in ISPM 18: *Guidelines for the use of irradiation as a phytosanitary measure* (FAO 2016c). Irradiation is recognised as an effective method for pest risk management when performed in approved facilities and at specific dose rates recognised as effective for target pest groups. Irradiation dose rates up to a maximum of 1,000 gray are permitted for quarantine purposes for food, including breadfruit, by Food Standards Australia New Zealand (FSANZ 2017).

The use of irradiation as a phytosanitary measure is subject to approval of the offshore irradiation facility by the Department of Agriculture. Exporting countries are required to provide a submission to the department, fulfilling the requirements as set out in ISPM 18 (FAO 2016c).

Management for mealybugs

The mealybugs *Dysmicoccus neobrevipes*, *Dysmicoccus nesophilus*, *Planococcus minor* and *Pseudococcus cryptus* were assessed as having an unrestricted risk estimate level that does not achieve the ALOP for Australia. Measures are therefore required to manage the biosecurity risk.

Recommended measure: Pre-export visual inspection and, if found, remedial action

All consignments of breadfruit for export to Australia will be subject to pre-export phytosanitary inspection by the NPPO of the exporting country to ensure that the breadfruit are free of the mealybugs *Dysmicoccus neobrevipes*, *Dysmicoccus nesophilus*, *Planococcus minor* and *Pseudococcus cryptus.*

Pre-export visual inspection must be undertaken by the NPPO of the exporting country in accordance with ISPM 23: *Guidelines for inspection* (FAO 2016d) and consistent with the principles of ISPM 13: *Methodologies for sampling consignments* (FAO 2016b). Export consignments found to contain any of these pests must be subject to remedial action. Remedial action may include withdrawing the consignment from export to Australia, or if available, application of an approved treatment to ensure that the pest is no longer viable.

5.1.3 Consideration of alternative measures

Consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2017a), the department will consider any alternative measure proposed by an NPPO, providing that it demonstrably manages the target pest to achieve the ALOP for Australia. Evaluation of such measures will require a technical submission from the NPPO that details the proposed measures, including suitable information to support claims of efficacy, for consideration by the department.

5.2 Operational system for the maintenance and verification of phytosanitary status

A system of operational procedures is necessary to maintain and verify the phytosanitary status of fresh breadfruit from Fiji, Samoa and Tonga. This is to ensure that the recommended risk management measures have been met and are maintained.

5.2.1 A system of traceability to source farms

The objectives of this recommended procedure are to ensure that:

- breadfruit are sourced only from registered orchards located in Fiji, Samoa and Tonga producing commercial quality fruit
- orchards from which breadfruit are sourced can be identified, so investigation and corrective action can be targeted, rather than applied to all contributing export orchards, in the event that live pests/viable pests are intercepted.

NPPOs must ensure that breadfruit for export to Australia can be traced back to registered commercial export orchards in Fiji, Samoa and Tonga. The NPPO is responsible for ensuring that export breadfruit growers are aware of pests of biosecurity concern to Australia and the required risk management measures.

5.2.2 Registration of packing houses and treatment providers and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- commercial quality breadfruit are sourced only from packing houses and treatment providers that are approved by the exporting country's NPPO
- treatment providers are approved by the exporting country's NPPO, and are capable of applying a treatment that suitably manages the target pests.

Export packing houses must be registered with the exporting country's NPPO before the commencement of harvest each season. The list of registered packing houses must be kept by the exporting country's NPPO. The exporting country's NPPO is required to ensure that the registered packing houses are suitably equipped and have a system in place to carry out the specified phytosanitary activities. Records of the exporting country's NPPO packing house audits must be made available to the Department of Agriculture upon request.

In circumstances where breadfruit undergo treatment prior to export, this process must be undertaken by treatment providers that have been registered with and audited by the exporting country's NPPO for that purpose. Records of the exporting country's NPPO registration requirements and audits are to be made available to the department upon request.

The approval of treatment providers by the exporting country's NPPO must include verification that suitable systems are in place to ensure compliance with the treatment requirements. This may include:

– documented procedures to ensure breadfruit is appropriately treated and safeguarded post-treatment
– staff training to ensure compliance with procedures
– record-keeping procedures
– suitability of facilities and equipment
– compliance with the exporting country NPPO's system of oversight of treatment application.

5.2.3 Packaging, labelling and containers

The objectives of this recommended procedure are to ensure that:

- breadfruit intended for export to Australia, and associated packaging, are not contaminated by quarantine pests or regulated articles (as defined in ISPM 5*: Glossary of phytosanitary terms* (FAO 2019)
- unprocessed packing material – which is not permitted, as it may vector other pests not associated with breadfruit – is not imported with the breadfruit
- all wood material associated with the consignment-used in packaging and transport of breadfruit must comply with the department's import conditions, as published on BICON
- secure packaging is used for export of breadfruit to Australia to prevent re-infestation during storage and transport and prevent escape of pests during clearance procedures on arrival in Australia. To make consignments insect proof and secure, at least one of the following packaging options must be used:
  - **Integral cartons -** produce may be packed in integral (fully enclosed) cartons (packages) with boxes having no ventilation holes and lids tightly fixed to the bases.
  - **Ventilation holes of cartons covered -** cartons (packages) with ventilation holes must have the holes covered/sealed with a mesh/screen of no more than 1.6 mm pore size and not less than 0.16 mm strand thickness. Alternatively, the vent holes could be taped over.
  - **Polythene liners -** vented cartons (packages) with sealed polythene liners/bags within are acceptable (folded polythene bags are acceptable).
  - **Meshed or shrink wrapped pallets or Unit Loading Devices (ULDs)-** ULDs transporting cartons with open ventilation holes/gaps, or palletised cartons with ventilation holes/gaps must be fully covered or wrapped with polythene/plastic/foil sheet or mesh/screen of no more than 1.6 mm diameter pore size.
  - **Produce transported in fully enclosed containers -** cartons (packages) with holes as loose boxes or on pallets may be transported in fully enclosed containers. Enclosed containers include 6-sided container with solid sides, or ULDS with tarpaulin sides that have no holes or gaps. The container must be transported to the inspection point intact.
- the packaged breadfruit are labelled with sufficient identifying information for purposes of traceability, including:
  - the treatment facility name/number and treatment identification reference/number
  - packing house registration reference/number.

Export packing houses and treatment providers (where applicable) must ensure clean, new packaging, and labelling are appropriate to maintain phytosanitary status of the export consignments.

5.2.4 Specific conditions for storage and movement

The objective of this recommended procedure is to ensure that the quarantine integrity of breadfruit during storage and movement is maintained.

Breadfruit for export to Australia that have been treated and inspected by the NPPO must be kept secure and segregated at all times from any fruit for domestic or other markets, and from untreated/non-inspected product, to prevent mixing or cross-contamination.

5.2.5 Freedom from trash

The objective of this recommended procedure is to ensure that breadfruit for export to Australia are free from trash (for example, loose stem and leaf material, seeds, soil, animal matter/parts or other extraneous material) and foreign matter.

Freedom from trash will be confirmed by the inspection procedures. Export lots or consignments found to contain trash or foreign matter must be withdrawn from export unless approved remedial action such as reconditioning is available and applied to the export consignment, and then re-inspected.

5.2.6 Pre-export phytosanitary inspection and certification

The objective of this recommended procedure is to ensure that Australia's import conditions have been met.

All consignments must be inspected in accordance with official procedures for all visually detectable quarantine pests and other regulated articles (including soil, animal and plant debris) using random samples of 600 units per phytosanitary certificate, or equivalent, as per ISPM 31: *Methodologies for sampling consignments* (FAO 2016e). One unit is considered to be a single breadfruit.

A phytosanitary certificate must be issued for each consignment upon completion of pre-export inspection and treatment to verify that the required risk management measures have been undertaken prior to export and the consignment meets Australia's import requirements.

Each phytosanitary certificate must include:

- a description of the consignment (including traceability information)
- details of disinfestation treatments (for example, high temperature forced air treatment)
- any other statements that may be required.

5.2.7 Phytosanitary inspection by the Australian Government Department of Agriculture

The objectives of this recommended procedure are to ensure that:

- consignments comply with Australian import requirements
- consignments are as described on the phytosanitary certificate
- quarantine integrity has been maintained.

On arrival in Australia, the department will:

- assess documentation to verify that the consignment is as described on the phytosanitary certificate, that required phytosanitary actions have been undertaken, and that product security has been maintained
- verify that the biosecurity status of the consignments of breadfruit from Fiji, Samoa and Tonga meet Australia's import conditions. When inspecting consignments the department will use random samples of 600 units, or equivalent, per phytosanitary certificate and inspection methods suitable for the commodity.

5.2.8 Remedial action(s) for non-compliance

The objectives of remedial action(s) for non-compliance are to ensure that:

- any quarantine pest or regulated article, including trash, is addressed by remedial action, as appropriate
- non-compliance with import requirement is addressed, as appropriate.

Any consignment that fails to meet Australia's import conditions will be subject to suitable remedial treatment where an effective treatment is available and biosecurity risks associated with applying the treatment can be effectively managed, or the imported consignment will be exported or destroyed.

Other actions, including partial or complete suspension of the import pathway, may be taken depending on the identity and/or importance of the pest intercepted, for example, fruit flies of economic importance.

In the event that breadfruit consignments are repeatedly non-compliant, the department reserves the right to suspend imports (either all imports, or imports from specific pathways) and conduct an audit of the risk management systems. Imports will recommence only when the department is satisfied that appropriate corrective action has been undertaken.

5.3 Uncategorised pests

If an organism that has not been categorised in this review, including contaminant pests, is detected on fresh breadfruit on arrival in Australia, it will require assessment by the department to determine its quarantine status and whether phytosanitary action is required.

Assessment will also be required if the detected species was categorised as not likely to be on the import pathway. If the detected species was categorised as being on the pathway, but assessed as having an unrestricted risk that achieves the ALOP for Australia, then it may require reassessment. The detection of any species of biosecurity concern not already identified in this risk analysis may result in remedial action and/or temporary suspension of trade while a review is conducted to ensure that existing measures continue to provide the appropriate level of protection for Australia.

5.4 Review of processes

5.4.1 Verification of protocol

Prior to or during the first season of trade, the department will verify the implementation of the required import conditions and phytosanitary measures, including of registration, operational procedures and treatment providers, where applicable. This may involve representatives from the department visiting areas in Fiji, Samoa and Tonga that produce breadfruit for export to Australia.

5.4.2 Review of policy

The department will review the import policy after a suitable volume of trade has been achieved. In addition, the department reserves the right to review the import policy as deemed necessary, including if there is reason to believe that any pest or phytosanitary status in Fiji, Samoa and Tonga has changed.

The exporting country's NPPO must inform the department immediately on detection of any new pests or diseases of breadfruit in Fiji, Samoa and Tonga that may be of potential biosecurity concern to Australia.

5.5 Meeting Australia's food laws

Imported food for human consumption must comply with the requirements of the *Imported Food Control Act 1992,* as well as Australian state and territory food laws. Among other things, these laws require all food, including imported food, to meet the standards set out in the Australia New Zealand Food Standards Code (the Code).

The Department of Agriculture administers the *Imported Food Control Act 1992.* This legislation provides for the inspection and control of imported food using a risk-based border inspection program, the Imported Food Inspection Scheme. More information on this inspection scheme, including the testing of imported food, is available from the department's website at: agriculture.gov.au/import/goods/food/inspection-compliance/inspection-scheme.

Food Standards Australia New Zealand (FSANZ) is responsible for developing and maintaining the Code, including Standard 1.4.2– Agvet chemicals. This standard is available on the Federal Register of Legislation (legislation.gov.au) or through the FSANZ website (foodstandards.gov.au/code/Pages/default.aspx).

Standard 1.4.2 and Schedules 20 and 21 of the Code set out the maximum residue limits (MRLs) and extraneous residue limits (ERLs) for agricultural or veterinary chemicals that are permitted in food, including imported food.

Standard 1.1.1 of the Code specifies that a food must not have, as an ingredient or a component, a detectable amount of an agricultural and veterinary chemical, or a metabolite or a degradation product of the agricultural and veterinary chemical, unless expressly permitted by the Code.

Standard 1.5.3 of the code stipulates the mandatory requirements where irradiation is applied as a phytosanitary measure, including the permitted fruit and vegetables, sources of irradiation, minimum and maximum absorbed dose, and the record-keeping and labelling requirements for irradiated produce. Irradiation dose rates up to a maximum of 1,000 gray are permitted by Food Standards Australia New Zealand for treatment of breadfruit for quarantine purposes (FSANZ 2017).

6 Conclusion

The findings of this final risk analysis for fresh breadfruit from Fiji, Samoa and Tonga are based on a comprehensive analysis of relevant scientific literature.

The Department of Agriculture considers that the risk management measures recommended in this report will provide an appropriate level of protection against the quarantine pests identified as associated with the importation of fresh breadfruit from Fiji, Samoa and Tonga.

Appendix A Categorisation of pests of fresh breadfruit from Fiji, Samoa and Tonga

This table identifies pests that have the potential to be present on fresh breadfruit grown in Fiji, Samoa and Tonga, using typical commercial production, postharvest and packing procedures, and imported into Australia.

The purpose of pest categorisation is to ascertain which of these pests require detailed assessment to determine whether additional phytosanitary measures are required. The steps in the pest categorisation process are considered sequentially, with the assessment terminating at 'Yes' for the third column (presence within Australia), except for pests that are present, but under official control and/or pests of regional concern. Assessment terminates at the first 'No' in any of the following columns.

In the final column of the table (column 7) the acronym 'WA' (Western Australia) is used to identify organisms that have been recorded in some regions of Australia but, due to interstate quarantine regulations, are considered pests of regional concern to Western Australia.

This is not a comprehensive list of all pests associated with breadfruit trees, and it does not include soil-borne pests and pathogens, wood-borers or root pests, as these are not directly related to the export pathway of fresh fruit. Other pests that may occasionally be detected in trade, which are not specifically associated with breadfruit, are not categorised here. Any such contaminant pests detected at the border are managed under existing standard operational procedures. It is important to note that any quarantine pests detected on arrival by quarantine inspection will be actioned as appropriate, even if they have not been assessed in this report.

The department is aware of recent changes in fungal nomenclature that no longer recognise separate names for different states of fungi with a pleomorphic life cycle. However, as the nomenclature for these fungi is in a phase of transition and many priorities of names are still to be resolved, this report uses generally accepted names, and provides alternatively used names as synonyms, where required. As official lists of accepted and rejected fungal names become available, the accepted names will be adopted.

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
ARTHROPODS						
Coleoptera (beetles)						
Ceresium unicolor (Fabricius, 1787) [Cerambycidae] Long-horned beetle	Fiji, Samoa (Stout 1982), Tonga (Secretariat of the Pacific Community 2019)	No record found	No. Breadfruit is a host, but beetle larvae bore into the branches (Stout 1982), and are not associated with fruit.	Assessment not required	Assessment not required	No
Ficicis porcatus (Chapuis, 1869) [Curculionidae] Bark beetle	Fiji, Samoa (Wood 1960), as *Hylesinus subcostatus* Eggers, 1923	Yes (Pullen, Jennings & Oberprieler 2014)	Assessment not required	Assessment not required	Assessment not required	No
Xylothrips religiosus (Boisduval, 1835) [Bostrichidae] Northern auger beetle	Fiji, Samoa (Stout 1982), Tonga (Secretariat of the Pacific Community 2019)	Yes (Wardlaw et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No
Diptera (flies)						
Atherigona poecilopoda Bezzi, 1928 [Muscidae] Muscid fly	Fiji, Samoa, Tonga (Pont 2016)	No record found	No. Associated with rotting fruit (Stout 1982). Unlikely to be present in export quality fruit.	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera distincta (Malloch, 1931) [Tephritidae] Fruit fly	Fiji, Samoa, Tonga (Hardy & Foote 2016; White & Elson-Harris 1994)	No record found	No. An old record from breadfruit in Tonga is considered to be doubtful by Leblanc *et al*. (2012). *Bactrocera distincta* was not bred from the 545 breadfruit collected during surveys in Fiji, Samoa and Tonga (Leblanc *et al*. 2012). This species has a preference for hosts in the Sapotaceae plant family (Tunupopo et al. 2002).	Assessment not required	Assessment not required	No
Bactrocera facialis (Coquillett, 1910) [Tephritidae] Fruit fly	Tonga (White & Elson-Harris 1994)	No record found	Yes. Breadfruit is a host (White & Elson-Harris 1994). Larvae have been found in fruit (Leblanc, Tora Vueti & Allwood 2013).	Yes. This is a polyphagous pest, with hosts widely distributed in Australia. Establishment and spread in warmer regions may be feasible if introduced.	Yes. This is a potentially serious pest if introduced into fruit and vegetable growing areas (White & Elson-Harris 1994). Hosts include avocado, capsicum, citrus, mango, peach and tomato (White & Elson-Harris 1994).	Yes

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Bactrocera passiflorae (Froggatt, 1911) [Tephritidae] Fijian fruit fly	Fiji (Heimoana et al. 1997; White & Elson-Harris 1994). Records from the Tongan archipelago (Niuatoputapu and Niuaf'ou islands) are likely to be the undescribed *Bactrocera passiflorae* (sp. nr.) (Leblanc, Tora Vueti & Allwood 2013; Vargas, Piñero & Leblanc 2015), which has a more restricted host range, and has not been reported on breadfruit (Leblanc et al. 2012)	No record found	Yes. Breadfruit is a host (Hinckley 1965a), and the larvae burrow in the fruit (Stout 1982).	Yes. This is a polyphagous pest, and hosts are widely available in Australia. Establishment and spread in warmer regions may be feasible if introduced.	Yes. This is an economically significant pest species (Tora Vueti et al. 1997), associated with a number of hosts including avocado, citrus, mango and papaya (White & Elson-Harris 1994).	Yes
Bactrocera xanthodes (Broun, 1905) [Tephritidae] Pacific fruit fly	Fiji, Samoa, Tonga (Leblanc *et al.* 2012)	No record found	Yes. Breadfruit is a host (Hinckley 1965a), and the larvae burrow in fruit (Stout 1982).	Yes. This is a polyphagous pest, and hosts are widely available in Australia. Hosts include capsicum, citrus, papaya, tomato and watermelon (White & Elson-Harris 1994).	Yes. This species is associated with a number of economically important hosts. It has the potential to become a very serious pest in areas where extensive horticulture is undertaken (Drew 1982).	Yes
Hemiptera (aphids, leafhoppers, mealybugs, scales, true bugs, whiteflies)						
Aonidiella aurantii (Maskell, 1879) [Diaspididae] Red scale	Fiji (Hodgson & Lagowska 2011), Samoa, Tonga (Williams & Watson 1988a)	Yes (Poole 2010)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Aonidiella inornata McKenzie, 1938 [Diaspididae] Papaya red scale	Fiji (Hodgson & Lagowska 2011), Samoa (Williams & Watson 1988a)	Yes (Donaldson & Tsang 2002; Poole 2010)	Assessment not required	Assessment not required	Assessment not required	No
Aphis craccivora Koch, 1854 [Aphididae] Cowpea aphid	Fiji (Hinckley 1965b), Samoa, Tonga (Carver, Hart & Wellings 1993)	Yes (Hollis & Eastop 2005)	Assessment not required	Assessment not required	Assessment not required	No
Aphis gossypii Glover, 1877 [Aphididae] Cotton aphid	Fiji , Samoa (Stout 1982), Tonga (Carver, Hart & Wellings 1993)	Yes (Hollis & Eastop 2005)	Assessment not required	Assessment not required	Assessment not required	No
Aspidiotus destructor Signoret, 1869 [Diaspididae] Coconut scale	Fiji, Samoa (Miller & Davidson 2005)	Yes (Donaldson & Tsang 2002; Poole 2010)	Assessment not required	Assessment not required	Assessment not required	No
Ceroplastes rubens Maskell, 1893 [Coccidae] Pink wax scale	Fiji, Samoa, Tonga (Stout 1982)	Yes (Qin & Gullan 1994)	Assessment not required	Assessment not required	Assessment not required	No
Ceroplastes stellifer (Westwood, 1871) [Coccidae] Stellate scale	Fiji (Hodgson & Lagowska 2011); Tonga (as *Vinsonia stellifera*) (Williams & Watson 1990)	Yes (Qin & Gullan 1994). Declared organism (Prohibited – s12) for WA (as *Vinsonia stellifera*) (Government of Western Australia 2018).	No. Recorded on breadfruit leaves in the Federated States of Micronesia (Nafus 1997). Typically associated with leaves and fleshy stems of host plants (Kosztarab 1997) and unlikely to be present on fruit.	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Chrysomphalus aonidum (Linnaeus, 1758) [Diaspididae] Florida red scale	Fiji (Williams and Watson 1988a), Samoa (García Morales et al. 2019)	Yes (Donaldson & Tsang 2002; Government of Western Australia 2018)	Assessment not required	Assessment not required	Assessment not required	No
Chrysomphalus dictyospermi (Morgan, 1889) [Diaspididae] Spanish red scale	Fiji, Samoa, Tonga (Williams & Watson 1988a)	Yes (Donaldson & Tsang 2002). Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	Yes. Breadfruit is a host. Typically found on the upper surface of the leaves (Stout 1982), but can also infest fruit (Miller & Davidson 2005).	Yes. This species has already established in Qld and has a wide distribution globally. It is highly polyphagous (García Morales et al. 2019) and feeds on many plants that are common in Australia.	Yes. This species is a serious pest of citrus in the western Mediterranean, Greece and Iran (García Morales et al. 2019).	Yes (WA)
Coccus capparidis (Sanders, 1906) [Coccidae] Capparis soft scale	Samoa, Tonga (Ben-Dov 1993)	No record found	No. Unlikely to be present on fruit as it occurs on the under surface of leaves of host plants (Gill, Nakahara & Williams 1977).	Assessment not required	Assessment not required	No
Coccus hesperidum Linnaeus, 1758 [Coccidae] Soft scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	Yes (Government of Western Australia 2018; Houston 2002)	Assessment not required	Assessment not required	Assessment not required	No
Coccus longulus (Douglas, 1887) [Coccidae] Long brown scale	Fiji, Samoa (Williams & Watson 1990)	Yes (García Morales et al. 2019; Houston 2002)	Assessment not required	Assessment not required	Assessment not required	No
Coccus viridis (Green, 1889) [Coccidae] Green coffee scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	Yes (Poole 2005)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Dialeuropora decempuncta (Quaintance & Baker, 1917) [Aleyrodidae] Breadfruit whitefly	Fiji and Tonga (Stout 1982).	Yes (Martin & Gillespie 2001).	Assessment not required	Assessment not required	Assessment not required	No
Dysmicoccus brevipes (Cockerell, 1893) [Pseudococcidae] Pineapple mealybug	Fiji, Samoa, Tonga (Williams & Watson 1988b).	Yes (García Morales et al. 2019).	Assessment not required	Assessment not required	Assessment not required	No
Dysmicoccus neobrevipes Beardsley, 1959 [Pseudococcidae] Grey pineapple mealybug	Samoa (Williams & Watson 1988b).	No record found.	Yes. Reported on breadfruit in Kiribati (Williams & Watson 1988b). This mealybug is found on aerial parts of the host plant, including fruit (Martin Kessing & Mau 2007b).	Yes. This species may potentially establish in tropical regions of Australia, and possibly subtropical areas, especially where pineapples are grown (Martin Kessing & Mau 2007b).	Yes. This species is one of the most serious mealybug pests in Hawaii. It is implicated in vectoring mealybug wilt and green spot disease in pineapples (Martin Kessing & Mau 2007b).	Yes
Dysmicoccus nesophilus Williams & Watson, 1988 [Pseudococcidae] Mealybug	Fiji, Samoa, Tonga (Williams & Watson 1988b).	No record found.	Yes. Intercepted in New Zealand on breadfruit imported from the Pacific (Williams & Watson 1988b)	Yes. This polyphagous species has spread throughout much of the South Pacific (Williams & Watson 1988b), so establishment is considered feasible.	Yes. A number of plant hosts are reported, including avocado, citrus, mango and papaya (Williams & Watson 1988b).	Yes
Ferrisia virgata (Cockerell, 1893) [Pseudococcidae] Striped mealybug	Fiji, Samoa, Tonga (Williams & Watson 1988b).	Yes (Poole 2010).	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Hemiberlesia cyanophylli (Signoret, 1869) [Diaspididae] Cyanophyllum scale	Fiji, Samoa, Tonga (as *Abgrallasipis cyanophylli*) (Williams & Watson 1988a)	Yes (Donaldson & Tsang 2002). Declared organism (Prohibited – s12) for WA (as *Abgrallaspis cyanophylli*) (Government of Western Australia 2018).	Yes. Breadfruit is a host (Stout 1982). It may be present on fruits, leaves and bark of host plants, but prefers the undersides of leaves (Miller & Davidson 2005).	Yes. Widespread in tropical and subtropical regions, and present in eastern Australia. It is a polyphagous species with a wide host range (García Morales et al. 2019; Watson 2017).	Yes. This species is highly polyphagous, causing damage to various ornamentals, palms, banana, avocado, cocoa, mango, guava and tea (García Morales et al. 2019; Miller & Davidson 2005; Watson 2017).	Yes (WA)
Hemiberlesia lataniae (Signoret, 1869) [Diaspididae] Latania scale	Fiji, Samoa, Tonga (Williams & Watson 1988a)	Yes (Donaldson & Tsang 2002)	Assessment not required	Assessment not required	Assessment not required	No
Hemiberlesia palmae (Cockerell, 1892) [Diaspididae] Palm scale	Fiji, Samoa, Tonga (Williams & Watson 1988a)	Yes (García Morales et al. 2019). Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	Yes. Recorded on breadfruit trees in Fiji and Kiribati (Williams & Watson 1988a). Usually present on leaves (Stout 1982) but may be found on fruit of some hosts (Watson 2017).	Yes. This species has established in many tropical countries. It has been reported from hosts belonging to at least 17 plant families, particularly palms (Watson 2017).	Yes. This is a pest of crops such as banana, citrus, cocoa, coconut and other palms. It often occurs in high numbers on the leaves of hosts, especially palms (Williams & Watson 1988a). Feeding weakens the host plant, reducing yield (Watson 2017).	Yes (WA)
Icerya seychellarum (Westwood, 1855) [Monophlebidae] Seychelles fluted scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	Yes (Houston 2002; Poole 2010)	Assessment not required	Assessment not required	Assessment not required	No
Kilifia acuminata (Signoret, 1873) [Coccidae] Acuminate scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	No record found	No. Breadfruit is a host, but this scale is normally found on leaves (Williams & Watson 1990).	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Lamenia caliginea (Stål, 1854) [Derbidae] Derbid planthopper	Fiji, Samoa, Tonga (Stout 1982)	No record found	No. While breadfruit is reported as a host (Stout 1982), this species feeds on phloem from leaf tissues. They are often found feeding along the underside midrib of leaves (Martin Kessing & Mau 1992). Unlikely to be present on fruit at harvest.	Assessment not required	Assessment not required	No
Levu vitiensis Kirkaldy, 1906 [Derbidae] Derbid planthopper	Fiji (Wilson 2009)	Yes (NSWDPI 2017)	Assessment not required	Assessment not required	Assessment not required	No
Maconellicoccus hirsutus (Green, 1908) [Pseudococcidae] Pink hibiscus mealybug	Fiji (Hodgkins & Lagowska 2011), Tonga (Ben-Dov 1994)	Yes (Ben-Dov 1994)	Assessment not required	Assessment not required	Assessment not required	No
Milviscutulus mangiferae (Green, 1889) [Coccidae] Mango shield scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	Yes (Grimshaw & Donaldson 2007)	Assessment not required	Assessment not required	Assessment not required	No
Nesocypselas dicysta Kirkaldy, 1908 [Tingidae] Lacebug	Fiji (Stout 1982)	No record found	No. Breadfruit is a host, but this species is associated with leaves (Stout 1982).	Assessment not required	Assessment not required	No
Nipaecoccus nipae (Maskell, 1893) [Pseudococcidae] Coconut mealybug	Fiji (Hogkins & Lagowska 2011)	No record found	No. Occurs on foliage of host plants (García Morales et al. 2019).	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Parasaissetia nigra (Nietner, 1861) [Coccidae] Nigra scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	Yes (García Morales et al. 2019)	Assessment not required	Assessment not required	Assessment not required	No
Pinnaspis strachani (Cooley, 1899) [Diaspididae] Hibiscus snow scale	Fiji, Samoa, Tonga (Williams & Watson 1988a)	Yes (Brooks 1964)	Assessment not required	Assessment not required	Assessment not required	No
Planococcus citri (Risso, 1813) [Pseudococcidae] Citrus mealybug	Fiji (Hinckley 1965b), Samoa, Tonga (Williams & Watson 1988b)	Yes (Poole 2010; Smith, Beattie & Broadley 1997)	Assessment not required	Assessment not required	Assessment not required	No
Planococcus minor (Maskell, 1897) [Pseudococcidae] Pacific mealybug	Fiji, Samoa, Tonga (García Morales et al. 2019)	Yes (Cox 1989). Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	Yes. Breadfruit is a host (Williams & Watson 1988b). This species can be spread via trade in fruit (Venette & Davis 2004).	Yes. This species is polyphagous, has a high reproductive rate, and has successfully established in a number of countries following its introduction (Francis *et al*. 2012).	Yes. This species is a serious pest in some countries. It can affect crops such as banana, citrus, cocoa, coffee, corn, grape, mango, potato and soybean (Venette & Davis 2004).	Yes (WA)
Prococcus acutissimus (Green, 1896) [Coccidae] Banana-shaped scale	Samoa (Ben-Dov 1993)	No record found	No. This species is usually found on the underside of leaves, positioned alongside the leaf veins (Gill, Nakahara & Williams 1977).	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudaonidia trilobitiformis (Green, 1896) [Diaspididae] Trilobite scale	Samoa (Secretariat of the Pacific Community 2019)	Yes (Donaldson & Tsang 2002). Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	No. Breadfruit is reported as a host in New Caledonia (Williams & Watson 1988a), but it occurs principally along the midrib and primary veins of leaves (Miller & Davidson 2005) and is not likely to be present on fruit.	Assessment not required	Assessment not required	No
Pseudaulacaspis pentagona (Targioni Tozzetti, 1886) [Diaspididae] White peach scale	Fiji, Samoa, Tonga (Williams & Watson 1988a)	Yes (Donaldson & Tsang 2002). Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	Yes. Recorded on breadfruit stems in the Federated States of Micronesia (Nafus 1997). Occurs on bark, leaves and fruit of hosts (Williams & Watson 1988a).	Yes. This species has a history of accidental introductions around the world, including Australia (CABI 2019), indicating that it can establish in new environments. It has already established in eastern Australia.	Yes. This scale is mainly a pest of deciduous fruits such as peach, currant, grape, kiwifruit and walnut. Affected plants lose vigour, and whole trees may die (CABI 2019).	Yes (WA)
Pseudococcus colliculosus Williams & Watson 1988 [Pseudococcidae] Mealybug	Described from specimens collected from the island of Lifuka, Tonga in 1977 (Williams and Watson 1988b)	No record found	No. Specimens were collected on a breadfruit tree in 1977, but actual host association is unknown. Not known to be present on other islands in Tonga where commercial production is undertaken.	Assessment not required	Assessment not required	No
Pseudococcus cryptus Hempel, 1918 [Pseudococcidae] Cryptic mealybug	Samoa (Williams & Watson 1988b)	Yes (QDAF 2012). Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	Yes. Recorded on breadfruit in Samoa. Attacks fruit of hosts (Williams & Watson 1988b).	Yes. This species is polyphagous and has a wide distribution globally, indicating potential to establish and spread.	Yes. This species is an important citrus pest in Japan (Arai 2002), and was a serious pest in Israel following its introduction there (García Morales et al. 2019).	Yes (WA)

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Pseudococcus longispinus (Targioni Tozzetti, 1867) [Pseudococcidae] Long-tailed mealybug	Fiji (Williams & Watson 1988b)	Yes (Ben-Dov 1994)	Assessment not required	Assessment not required	Assessment not required	No
Pyrrhoneura saccharicida Kirkaldy, 1906 [Derbidae] Sugarcane derbid planthopper	Fiji (Hinckley 1965b; Wilson 2009), Samoa (Muir 1927), Tonga (Fennah 1967)	No record found	No. Recorded on breadfruit leaves in Fiji (Hinckley 1965b). Derbidae are phloem feeders (Fletcher 2014) and are unlikely to be present on mature breadfruit at harvest.	Assessment not required	Assessment not required	No
Russellaspis pustulans (Cockerell, 1892) [Asterolecaniidae] Oleander pit scale	Fiji (Williams & Watson 1990)	No record found	No. Breadfruit is a host, but it is only associated with leaves (Stout 1982). Unlikely to be present on fruit.	Assessment not required	Assessment not required	No
Saissetia coffeae (Walker, 1852) [Coccidae] Brown scale	Fiji, Samoa, Tonga (Williams & Watson 1990)	Yes (García Morales et al. 2019)	Assessment not required	Assessment not required	Assessment not required	No
Tinginotum knowlesi (Kirkaldy, 1908) [syn.: *Nesodaphne knowlesi* Kirkaldy [Miridae] Mirid bug	Fiji (Hinckley 1965b), Samoa (Eyles 2000), Tonga (Secretariat of the Pacific Community 2019)	No record found	No. Recorded on breadfruit in Niue (Eyles 2000). Mirid bugs feed on meristems, new foliage, flower buds, flowers and developing seeds (Wheeler 2000). This species is unlikely to be present on mature fruit.	Assessment not required	Assessment not required	No
Toxoptera aurantii (Boyer de Fonscolombe, 1841) [Aphididae] Soursop aphid	Fiji, Samoa, Tonga (Carver, Hart & Wellings 1993).	Yes (Hollis & Eastop 2005)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Lepidoptera (butterflies, moths)						
Eudocima phalonia (Linnaeus, 1763) [syn.: *Eudocima fullonia* (Clerck, 1764)] [Noctuidae] Fruit piercing moth	Fiji, Samoa, Tonga (Stout 1982).	Yes (Waterhouse & Norris 1987)	Assessment not required	Assessment not required	Assessment not required	No
CHLOROPHYTA: Ulvophyceae						
Trentepohliales (green algae)						
Cephaleuros virescens Künze ex E.M. Fries [Trentepohliaceae] Algal leafspot	Samoa, Tonga (Dingley, Fullerton & McKenzie 1981).	Yes (Johnson & Hobson 1982)	Assessment not required	Assessment not required	Assessment not required	No
CHROMALVEOLATA						
Phytophthora palmivora (E.J. Butler) E.J. Butler [Peronosporaceae] Bud rot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Cook & Dubé 1989; Sampson & Walker 1982; Shivas 1989; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
FUNGI						
Cladosporium oxysporum Berk. & M.A. Curtis [Cladosporiaceae] Leaf scorch	Fiji (Firman 1972)	Yes (Bensch et al. 2012)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei [Corynesporascaceae] Leaf spot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Hyde & Alcorn 1993) Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	No. Usually on leaves, often as a secondary pathogen on damaged tissue (Dingley, Fullerton & McKenzie 1981). Not likely to be present on fruit.	Assessment not required	Assessment not required	No
Colletotrichum gloeosporioides (Penz.) Penz. and Sacc [Syn: *Glomerella cingulata* (Stonem.) Spaulding and H. Schrenk] [Glomerellaceae] Anthracnose	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Cook & Dubé 1989; Letham 1995; Sampson & Walker 1982; Shivas 1989; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Earliella scabrosa (Pers.) Gilb. & Ryvarden [syn.: *Trametes corrugata* (Pers.) Bres. [Polyporaceae] Wood rot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Government of Western Australia 2018; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Erythricium salmonicolor (Berk. & Broome) Burds. [Syn.: *Corticium salmonicolor* (Berk. & Broome); *Phanerochaete salmonicolor* (Berk. & Broome) Jülich] [Corticiaceae] Pink disease	Fiji, Samoa (Dingley, Fullerton & McKenzie 1981)	Yes (Hyde & Alcorn 1993) Declared organism (Prohibited – s12) for WA (Government of Western Australia 2018).	No. Causes die-back of woody shrubs and trees. Usually on dead wood (Dingley, Fullerton & McKenzie 1981) on the trunk, stems and twigs (Sangchote, Wright & Johnson 2003). Not likely to be present on fruit.	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Fusarium solani (Mart.) Sacc. [Syn.: *Haematonectria haematococca* (Berk. & Broome) Samuels & Rossman; *Nectria haematococca* Berk & Broome] [Nectriaceae] Stem and root rot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Cook & Dubé 1989; Shivas 1989)	Assessment not required	Assessment not required	Assessment not required	No
Hysterostomella spurcaria (Berk. & Broome) Höhn. [Syn.: *Cocconia spurcaria* (Berk. & Broome)] [Parmulariaceae] Black leaf fleck	Fiji, Samoa (Dingley, Fullerton & McKenzie 1981)	No record found	No. Recorded on breadfruit trees in Fiji and Samoa. Infection results in circular black cuticular spots 1-4 mm diameter on upper leaf surfaces (Dingley, Fullerton & McKenzie 1981). Not likely to be present on fruit.	Assessment not required	Assessment not required	No
Lasiodiplodia theobromae (Pat.) Griffon & Maubl. [Botryosphaeriaceae] Fruit rot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Shivas 1989; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Phellinus noxius (Corner) G. Cunn. [Hymenochaetaceae] Basal rot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
***Physopella artocarpi* (**Berk. & Broome) Arthur [Phakopsoraceae] Leaf rust	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	No record found	No. Recorded on breadfruit trees in Fiji, Samoa and Tonga (Dingley, Fullerton & McKenzie 1981). Usually only affects older leaves, and does not appear to damage the tree (Dingley, Fullerton & McKenzie 1981). Rust is not likely to be present on fruit.	Assessment not required	Assessment not required	No
Pseudocercospora artocarpi (Syd. & P. Syd.) Deighton [Mycosphaerellaceae] Leaf spot	Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	No record found	No. Recorded on breadfruit trees in Samoa and Tonga. Usually only present on mature leaves, causing distinct, irregular brown leaf blotches (Dingley, Fullerton & McKenzie 1981). Not likely to be present on fruit.	Assessment not required	Assessment not required	No
Pseudocercospora artocarpicola Braun & McKenzie [Mycosphaerellaceae] Leaf blotch	Fiji, Samoa (McKenzie 2014)	No record found	No. Recorded on breadfruit leaves in Vanuatu (Braun, Mouchacca & McKenzie 1999) and Nauru (McKenzie 2014). Blackish sooty mould growth on the lower surface of the leaves (McKenzie 2014). Not likely to be present on fruit.	Assessment not required	Assessment not required	No

Pest	Present in Fiji, Samoa or Tonga	Present within Australia	Potential to be on fresh breadfruit pathway	Potential for establishment and spread	Potential for economic consequences	Pest risk assessment required
Rhizopus stolonifer (Ehrenb.) Vuill. [Syn.: *Rhizopus artocarpi* Racib.] [Rhizopodaceae] Fruit rot	Fiji, Samoa (Dingley, Fullerton & McKenzie 1981)	Yes (Cook & Dubé 1989; Sampson & Walker 1982; Shivas 1989; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Schizophyllum commune Fr. [Schizophyllaceae] Wood rot	Fiji, Samoa, Tonga (Dingley, Fullerton & McKenzie 1981)	Yes (Cook & Dubé 1989; Sampson & Walker 1982; Shivas 1989; Simmonds 1966)	Assessment not required	Assessment not required	Assessment not required	No
Septoria eburnea Höhn. [Mycosphaerellaceae] Leaf spot	Samoa (Dingley, Fullerton & McKenzie 1981)	No record found	No. Recorded on breadfruit trees in Samoa (Dingley, Fullerton & McKenzie 1981). Causes minor leaf spots on breadfruit (Sangchote *et al.* 2003), but no association with mature fruit is reported. Not likely to be present on fruit.	Assessment not required	Assessment not required	No
Trametes hirsuta (Wulfen) Lloyd [Polyporaceae] Hairy bracket	Samoa (Dingley, Fullerton & McKenzie 1981)	Yes (May et al. 2003)	Assessment not required	Assessment not required	Assessment not required	No

Appendix B Issues raised in stakeholder comments

This section includes key technical issues raised by stakeholders during consultation on the draft report, and the department's responses. Additional information on other issues commonly raised by stakeholders, which may be outside the scope of this technical report, is available on the department's website.

Issue 1: The fruit fly management practices for all countries to be included in the report (page 19 of draft report).

Response: Fiji, Samoa and Tonga undertake an integrated approach to managing fruit flies for the export of fresh breadfruit. The fruit fly management practices adopted for breadfruit production for export are very similar across the three assessed countries. These practices are guided by the existing requirements stipulated in the bilateral quarantine arrangements (BQAs) with New Zealand for market access of host material of fruit fly species of economic significance, which includes breadfruit. The BQAs cover the requirements for grower and site registration, field hygiene, bait spraying programs for fruit flies, harvesting, licensing of treatment and packing facilities, and inspection and audit procedures.

Additional information has been included in Chapter 3: 'Commercial production practices', which outlines the fruit fly management practices that occur in Fiji, Samoa and Tonga.

Issue 2: Clarify the rationale for applying the HTFA treatment process, currently accepted for the importation of fresh papaya from Fiji, to breadfruit (page 42 of draft report).

Response: HTFA treatment has been successfully used by Fiji, Samoa and Tonga as a phytosanitary measure to manage fruit flies for the export of papaya, eggplant, mango and breadfruit to New Zealand for many years. Small volumes of HTFA-treated goods have also been exported to New Zealand from the Cook Islands, New Caledonia and Vanuatu. Additionally, Hawaii has exported organic papayas to the mainland United States, using HTFA treatment for fruit fly pests of concern as an alternative to irradiation.

The efficacy of HTFA treatment against *Bactrocera passiflorae*, *Bactrocera xanthodes* and *Bactrocera facialis* (as well as *Bactrocera dorsalis*, *Bactrocera melanotus*, *Ceratitis capitata* and *Zeugodacus cucurbitae*) has been demonstrated experimentally, and through more than two decades of trade, for a range of fruit fly-host commodities. The HTFA treatment protocol known to be effective against these fruit fly species requires the fruit core to be heated to at least 47.2°C and held at that temperature for a minimum of 20 minutes. This protocol is the same for papaya, breadfruit, eggplant and mango (the total treatment time differs between commodities, due to the varying time taken to heat the core of the fruit to the target temperature, and then to cool the fruit to room temperature afterwards).

Australia has permitted the import of HTFA-treated papaya from Fiji under this same treatment protocol since 2004. HTFA treatment has been found to be an effective treatment for managing the biosecurity risk posed by fruit flies to achieve Australia's appropriate level of protection (ALOP). In addition to the original efficacy studies conducted to gain market access to New Zealand, a further two confirmatory studies were undertaken by Fiji before Australia approved the treatment for fresh papaya.

Given its demonstrated efficacy and acceptance internationally for the treatment of breadfruit, the department considers HTFA to be an appropriate treatment to mitigate the biosecurity risks associated with fruit flies in breadfruit imported from Fiji, Samoa and Tonga. The HTFA treatment facilities will need to be approved by the Department of Agriculture before trade can commence. Exporting countries are required to provide a submission to the department to demonstrate they have processes and procedures for the registration, approval and audit of treatment facilities. The department may request on-site verification of the treatment facilities.

Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2019).
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Appropriate level of protection (ALOP) for Australia	The *Biosecurity Act 2015* defines the appropriate level of protection (or ALOP) for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Area	An officially defined country, part of a country or all or parts of several countries.
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans.
Australian territory	Australian territory as referenced in the *Biosecurity Act 2015* refers to Australia, Christmas Island, Cocos (Keeling) Islands and Norfolk Island.
Biosecurity	The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment.
Biosecurity measures	The *Biosecurity Act 2015* defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies.
Biosecurity risk	The *Biosecurity Act 2015* refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities.
Biosecurity import risk analysis (BIRA)	The *Biosecurity Act 2015* defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or the class of goods, to a level that achieves the ALOP for Australia. The risk analysis process is regulated under legislation.
Consignment	A quantity of plants, plant products or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities) (FAO 2019).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2019).
Crawler	Intermediate mobile nymph stage of certain arthropods.
The department	The Australian Government Department of Agriculture.
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2019).
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment.
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2019).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2019).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2019).

Term or abbreviation	Definition
Genus	A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.
Goods	The *Biosecurity Act 2015* defines goods as an animal, a plant (whether moveable or not), a sample or specimen of a disease agent, a pest, mail or any other article, substance or thing (including, but not limited to, any kind of moveable property).
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2019).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2019).
Infection	The internal ‘endophytic’ colonisation of a plant, or plant organ, generally associated with the development of disease symptoms as the integrity of cells and/or biological processes are disrupted.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2019).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (FAO 2019).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced or used (FAO 2019).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2019).
International Plant Protection Convention (IPPC)	The IPPC is an international plant health agreement, established in 1952, that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. The IPPC provides an international framework for plant protection that includes developing International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources.
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on Phytosanitary Measures or the Commission on Phytosanitary Measures, established under the IPPC (FAO 2019).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2019).
Larva	A juvenile form of animal with indirect development, undergoing metamorphosis (for example, insects or amphibians).
Mature fruit	Commercial maturity is the start of the ripening process. The ripening process will then continue and provide a product that is consumer-acceptable. Maturity assessments include colour, starch index, soluble solids content, flesh firmness, acidity, and ethylene production rate.
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2019).
Non-regulated risk analysis	Refers to the process for conducting a risk analysis that is not regulated under legislation (Biosecurity import risk analysis guidelines 2016).
Nymph	The immature form of some insect species that undergoes incomplete metamorphosis. It is not to be confused with larva, as its overall form is already that of the adult.
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2019).

Term or abbreviation	Definition
Orchard	A contiguous area of trees operated as a single entity. Within this report a single orchard is covered under one registration and is issued a unique identifying number.
Pathogen	A biological agent that can cause disease to its host.
Pathway	Any means that allows the entry or spread of a pest (FAO 2019).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2019).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2019).
Pest free area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (FAO 2019).
Pest free place of production	Place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2019).
Pest free production site	A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2019).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2019).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences (FAO 2019)).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2019).
Pest status (in an area)	Presence or absence, at the present time, of a pest in an area, including where appropriate its distribution, as officially determined using expert judgement on the basis of current and historical pest records and other information (FAO 2019).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model of certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2019).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2019).
Phytosanitary measure	Phytosanitary relates to the health of plants. Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2019). In this risk analysis the term 'phytosanitary measure' and 'risk management measure' may be used interchangeably.
Phytosanitary procedure	Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2019).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2019).
Polyphagous	Feeding on a relatively large number of hosts from different plant families and/or genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2019).
Production site	In this report, a production site is a continuous planting of breadfruit trees treated as a single unit for pest management purposes. If an orchard is

Term or abbreviation	Definition
	subdivided into one or more units for pest management purposes, then each unit is a production site. If the orchard is not subdivided, then the orchard is also the production site.
Quarantine	Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2019).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2019).
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2019).
Regulated pest	A quarantine pest or a regulated non-quarantine pest (FAO 2019).
Restricted risk	Restricted risk is the risk estimate when risk management measures are applied.
Risk analysis	Refers to the technical or scientific process for assessing the level of biosecurity risk associated with the goods, or the class of goods, and if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or class of goods to a level that achieves the ALOP for Australia.
Risk management measure	A condition that must be met to manage the level of biosecurity risk associated with the goods or the class of goods, to a level that achieves the ALOP for Australia. In this risk analysis, the term 'risk management measure' and 'phytosanitary measure' may be used interchangeably.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2019).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Surveillance	An official process which collects and records data on pest occurrence or absence by surveying, monitoring or other procedures.
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests.
Trash	Soil, splinters, twigs, leaves and other plant material, other than fruit as defined in the scope of this risk analysis. For example, stem and leaf material, seeds, soil, animal matter/parts or other extraneous material.
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2019).
Unrestricted risk	Unrestricted risk is the risk estimate in the absence of any risk management measures being applied on the export pathway.
Vector	An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another.
Viable	Alive, able to germinate or capable of growth.

References

Allwood, A & Leblanc, L 1997, ‘Losses Caused by Fruit Flies (Diptera: Tephritidae) in Seven Pacific Island Countries’, *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji 28-31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 208-11.

Allwood, A, Vueti, E, Leblanc, L & Bull, R 2002, ‘Eradication of introduced *Bactrocera* species (Diptera: Tephritidae) in Nauru using male annihilation and protein bait application techniques’, in *Turning the tide: the eradication of invasive species*, Veitch, C & Clout, M (eds).

Amice, R & Sales, F 1997, ‘Seasonal Abundance of Fruit Flies in New Caledonia’, *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji 28–31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 134–9.

Arai, T 2002, ‘Attractiveness of sex pheromone of *Pseudococcus cryptus* Hempel (Homoptera : Pseudococcidae) to adult males in a citrus orchard’, *Applied Entomology and Zoology*, vol. 37, pp. 69-72.

Armstrong, J 1997, ‘Quarantine Treatment Options for Fruit Fly Host Commodities for Pacific Island Countries’, *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji 28–31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 222-4.

Bateman, MA 1972, ‘The ecology of fruit flies’, *Annual Review of Entomology*, vol. 17, pp. 493-518.

Ben-Dov, Y 1993, *A systematic catalogue of the soft scale insects of the world (Homoptera: Coccoidea: Coccidae) with data on geographical distribution, host plants, biology and economic importance*, Arnett, RHJ (ed), Sandhill Crane Press, Inc., Gainesville.

-- -- 1994, *A systematic catalogue of the mealy bugs of the world (Insecta: Homoptera: Coccoidea: Pseudococcidae and Putoidae) with data on geographical distribution, host plants, biology and economic importance*, Intercept Limited, Andover.

Bensch, K, Braun, U, Groenewald, J & Crous, P 2012, ‘The genus *Cladosporium*’, *Studies in Mycology*, vol. 72, no. 1, pp. 1-451.

Biosecurity Australia 2002, *Quarantine requirements for import of Fijian papaya to Australia*, Biosecurity Australia, Agriculture, Fisheries and Forestry - Australia (AFFA), Canberra, available at http://www.agriculture.gov.au/biosecurity/risk-analysis/plant/papaya-fiji (pdf 134 kb).

-- -- 2005, *Final report: extension of existing policy for sweet oranges from Italy*, Department of Agriculture, Fisheries and Forestry, Canberra.

-- -- 2006, *Policy for the importation of fresh mangoes (Mangifera indica L.) from Taiwan*, Biosecurity Australia, Department of Agriculture, Fisheries and Forestry, Canberra, available at http://www.agriculture.gov.au/biosecurity/risk-analysis/plant/mangoes-taiwan (pdf 846 kb).

-- -- 2008, *Final import risk analysis report for fresh mango fruit from India*, Biosecurity Australia, Department of Agriculture, Fisheries and Forestry, Canberra, available at http://www.agriculture.gov.au/biosecurity/risk-analysis/plant/mangoes-from-india (pdf 1.3 mb).

-- -- 2009, *Final import risk analysis report for fresh greenhouse-grown capsicum (paprika) fruit from the Republic of Korea*, Biosecurity Australia, Department of Agriculture, Fisheries and Forestry, Canberra.

Biosecurity Authority Fiji 2017, 'Biosecurity Import Risk Analysis (BIRA) for Fijian breadfruit, *Artocarpus altilis* (Parkinson ex F.A. Zorn) Fosberg',in *Import proposal for Fijian breadfruit to Australia*, Armstrong, J (ed). Suva, Fiji.

Braun, U, Mouchacca, J & McKenzie, E 1999, 'Cercosporoid hyphomycetes from New Caledonia and some other South Pacific islands', *New Zealand Journal of Botany*, vol. 37, pp. 297-327.

Brooks, J 1964, 'New records of Coleoptera in Australia', *Australian Journal of Entomology*, vol. 64, p. 85.

CABI 2019, 'Crop Protection Compendium', CAB International, Wallingford, UK, available at http://www.cabi.org/cpc/, accessed 2019.

Cantrell, BK, Chadwick, B & Cahill, A 2002, *Fruit fly fighters: eradication of the papaya fruit fly*, CSIRO Publishing, Collingwood.

Carver, M, Hart, PJ & Wellings, PW 1993, 'Aphids (Hemiptera: Aphididae) and associated biota from the Kingdom of Tonga, with respect to biological control', *Pan-Pacific Entomologist*, vol. 69, no. 3, pp. 250-60.

Christenson, LD & Foote, RH 1960, 'Biology of fruit flies', *Annual Review of Entomology*, vol. 5, pp. 171-92.

Clare, G 1997, 'Rearing of *Bactrocera melanotus* and *B. xanthodes* (Diptera: Tephritidae) for postharvest disinfestation research', *New Zealand Journal of Zoology*, vol. 24, pp. 193-8.

Cook, RP & Dubé, AJ 1989, *Host-pathogen index of plant diseases in South Australia*, Field Crops Pathology Group, South Australian Department of Agriculture, Adelaide.

Cox, JM 1989, 'The mealybug genus *Planococcus* (Homoptera: Pseudococcidae)', *Bulletin of the British Museum (Natural History), Entomology*, vol. 58, no. 1, pp. 1-78.

DAFF 2004, *Mangosteen fruit from Thailand: final import risk analysis report*, Department of Agriculture, Fisheries and Forestry, Canberra, available at http://www.agriculture.gov.au/SiteCollectionDocuments/ba/memos/2004/plant/fin_ira_mangosteen.pdf (pdf 674.85).

-- -- 2012, *Final import risk analysis report for the importation of fresh decrowned pineapple (Ananas comosus (L.) Merr.) fruit from Malaysia*, Department of Agriculture, Fisheries and Forestry, Canberra, available at http://www.agriculture.gov.au/biosecurity/risk-analysis/plant/pineapples-from-malaysia/ba2012-27-final-malaysian-pineapples (PDF 1.4 mb).

-- -- 2013, *Final pest risk analysis report for the importation of fresh island cabbage leaves from the Pacific (Cook Islands, Fiji, Samoa, Tonga and Vanuatu)*, Department of Agriculture, Fisheries and Forestry, Canberra, available at http://www.agriculture.gov.au/biosecurity/risk-analysis/plant/island-cabbage/ba2013-14-finalpra-island-cabbage (pdf 32 kb).

Dingley, JM, Fullerton, RA & McKenzie, EHC 1981, *Survey of agricultural pests and diseases, technical report, volume 2: records of fungi, bacteria, algae, and angiosperms pathogenic of plants in Cook Islands, Fiji, Kiribati, Niue, Tonga, Tuvalu, and Western Samoa*, Food and Agriculture Organization of the United Nations, Rome.

Donaldson, J & Tsang, K 2002, *Hemiptera: Diaspididae*, Australian Faunal Directory, Australian Biological Resources Study, Canberra, available at http://environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/Diaspididae.

Drew, R 1982, 'Taxonomy', in *Economic Fruit Flies of the South Pacific Region*, Drew, R, Hooper, G & Bateman, M (eds), Queensland Department of Primary Industries, Brisbane., Brisbane.

Duke, J & duCellier, J 1993, *CRC handbook of alternative cash crops*, CRC Press Inc, Boca Raton, Florida.

Elevitch, C, Ragone, D & Cole, I 2014, '*Breadfruit production guide: recommended practices for growing, harvesting, and handling*', Breadfruit Institute of the National Tropical Botanical Garden Kalaheo, Hawaii.

Eyles, A 2000, '*Tinginotum* Kirkaldy in New Zealand and Australia: A shared new species, and a new species of *Tinginotopsis poppius* from Norfolk Island (Hemiptera: Miridae)', *New Zealand Journal of Zoology*, vol. 27, pp. 111–9.

FAO 2016a, *International Standards for Phytosanitary Measures (ISPM) no. 2: Framework for pest risk analysis*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2016b, *International Standards for Phytosanitary Measures (ISPM) no. 13: Guidelines for the notification of non-compliance and emergency action*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2016c, *International Standards for Phytosanitary Measures (ISPM) no. 18: Guidelines for the use of irradiation as a phytosanitary measure*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2016d, *International Standards for Phytosanitary Measures (ISPM) no. 23: Guidelines for inspection*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2016e, *International Standards for Phytosanitary Measures (ISPM) no. 31: Methodologies for sampling of consignments* Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2017a, *International Standards for Phytosanitary Measures (ISPM) no. 11: Pest risk analysis for quarantine pests*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2017b, *International Standards for Phytosanitary Measures (ISPM) no. 28 Annex 7: Irradiation treatment for fruit flies of the family Tephritidae (generic)*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

-- -- 2019, *International Standards for Phytosanitary Measures (ISPM) no. 5: Glossary of phytosanitary terms*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at https://www.ippc.int/en/core-activities/standards-setting/ispms/.

Fennah, R 1967, 'New species and new records of Fulgoroidea (Homoptera) from Samoa and Tonga', *Pacific Insects*, vol. 9, pp. 29–72.

Firman, ID 1972, *A list of fungi and plant parasitic bacteria, viruses and nematodes in Fiji*, Commonwealth Mycological Institute, Surrey.

Fletcher, M 2014, *Family Derbidae Spinola, 1839*, Australian Biological Resources Study,, Canberra, available at www.biodiversity.org.au/afd/taxa/DERBIDAE.

Francis, AW, Kairo, MTK, Roda, AL, Liburd, OE & Polar, P 2012, 'The passionvine mealybug, *Planococcus minor* (Maskell) (Hemiptera: Pseudococcidae), and its natural enemies in the cocoa agroecosystem in Trinidad', *Biological Control*, vol. 60, no. 3, pp. 290-6.

FSANZ 2017, *Australia New Zealand Food Standards Code: standard 1.5.3: irradiation of food*, Food Standards Australia New Zealand (FSANZ), available at https://www.legislation.gov.au/Details/F2017C00053 (pdf 0.4 mb).

García Morales, M, Denno, B, Miller, D, Miller, G, Ben-Dov, Y & Hardy, N 2019, 'ScaleNet: A literature-based model of scale insect biology and systematics', available at www.scalenet.info.

Gill, RJ, Nakahara, S & Williams, ML 1977, 'A review of the genus *Coccus* Linnaeus in America north of Panama (Homoptera: Coccoidea: Coccidae).', *Occasional Papers in Entomology*, vol. 24, pp. 1-44.

Government of Western Australia 2018, 'Western Australia Organism List (WAOL)', available at https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol, accessed 2019.

Grimshaw, JF & Donaldson, JF 2007, 'New records of mango shield scale *Milviscutulus mangiferae* (Green) (Hemiptera: Coccidae) and *Brevennia rehi* (Lindinger) (Hemiptera: Pseudococcidae) in North Queensland', *Australian Journal of Entomology*, vol. 46, pp. 96-8.

Hardy, D & Foote, R 2016, *Family Tephritidae*, Catalog of the Diptera of the Australasian and Oceanian Regions (online version), available at www.hbs.bishopmuseum.org/aocat/tephritidae.html

Heimoana, V, Tunupopo, F, Toleafoa, E & Fakanaiki, C 1997, 'The Fruit Fly Fauna of Tonga, Western Samoa, American Samoa and Niue', *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji 28-31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 57–9.

Hinckley, A 1965a, 'Fruit fly infestation and parasitization in Fiji', *Proceedings of the Hawaiian Entomological Society*, vol. 19, pp. 91-5.

-- -- 1965b, 'Trophic records of some insects, mites and ticks in Fiji', *Bulletin of the Department of Agriculture, Fiji*, vol. 45, pp. 1-116.

Hodgson, CJ & Lagowska, 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*, vol. 2766, pp. 1-29.

Hollis, D & Eastop, VF 2005, *Superfamily Aphidoidea*, Australian Faunal Directory, Australian Biological Resources Study, available at http://environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/aphidoidea.

Houston, W 2002, *Superfamily Coccoidea (mealy bugs, scale insects)*, Australian Faunal Directory, Australian Biological Resources Study, Canberra, available at https://biodiversity.org.au/afd/taxa/COCCOIDEA.

Hyde, KD & Alcorn, JL 1993, 'Some disease-associated microorganisms on plants of Cape York Peninsula and Torres Strait islands', *Australian Plant Pathology*, vol. 22, no. 3, pp. 73-83.

Johnson, GI & Hobson, FR 1982, 'Red rust *(Cephaleuros virescens)* on tea in Queensland', *Australasian Plant Pathology*, vol. 11, no. 2, pp. 16-.

Kim, SC, Song, H & Kim, D 2008, 'Effect of temperature on the development and fecundity of the cryptic mealybug, *Pseudococcus cryptus,* in the laboratory', *Journal of Asia-Pacific Entomology*, vol. 11, pp. 149-53.

Kosztarab, M 1997, 'Ornamental and house plants', in *Soft scale insects – their biology, natural enemies and control*, Hodgson, YB-DC (ed), Elsevier Science, Amsterdam, Netherlands.

Leblanc, L, Tora Vueti, E & Allwood, A 2013, 'Host plant records for fruit flies (Diptera: Tephritidae: Dacini) in the Pacific Islands: 2. Infestation statistics on economic hosts', *Proceedings of the Hawaiian Entomological Society*, vol. 45, pp. 83–117.

Leblanc, L, Vargas, R & Putoa, R 2013, 'From eradication to containment: invasion of French Polynesia by Bactrocera dorsalis (Hendel) (Diptera: Tephritidae) and releases of two natural enemies: a 17-year case study', *Proceedings of the Hawaiian Entomological Society*, vol. 45, pp. 31-43.

Leblanc, L, Vueti, ET, Drew, RAI & Allwood, AJ 2012, 'Host plant records for fruit flies (Diptera: Tephritidae: Dacini) in the Pacific Islands', *Proceedings of the Hawaiian Entomological Society*, vol. 44, pp. 11-53.

Letham, DB 1995, *Host-pathogen index of plant diseases in New South Wales*, New South Wales Agriculture, Rydalmere.

Leweniqila, L, Allwood, A, Tora Vueti, E, Raluht, L & Balawakula, A 1997a, 'Rate of development of immature stages of *Bactrocera passiflorae* (Froggatt) in eggplant and pawpaw', *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji, 28-31 October 1996 28-31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 168-70.

Leweniqila, L, Heimoana, V, Purea, M, Munro, L, Allwood, A, Ralulu, L & Tora Vueti, E 1997b, 'Seasonal abundances of *Bactrocera facialis* (Coquillett), *B. passiflorae* (Froggatt), *B. xanthodes* (Broun) and *B. melanotus* (Coquillett) in orchard and forest habitats', *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji, 28-31 October 1996, 28-31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 121-4.

Litsinger, JA, Fakalata, OK, Faluku, TL, Crooker, PS & von Keyserlingk, N 1991, 'A study of fruit fly species (Tephritidae) occurring in the Kingdom of Tonga', *First International Symposium of Fruit Flies in the Tropics, Kuala Lumpur, Malaysia, 14-16 March 1988*, Malaysian Agricultural Research and Development Institute, Kuala Lumpur, Malaysia, pp. 177-90.

MAF 2007, *Market access submission for the export of breadfruit (Artocarpus altilis) from Samoa to Australia*, Government of Samoa Ministry of Agriculture and Fisheries.

Martin, JH & Gillespie, PS 2001, *Superfamily Aleyrodoidea: white flies*, Australian Biological Resources Study: Australian Faunal Directory, available at http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/Aleyrodoidea.

Martin Kessing, J & Mau, R 1992, '*Lamenia caligena* (Stal)', *Crop Knowledge Master*, Extension Entomology and UH-CTAHR Integrated Pest Management Program, available at www.extento.hawaii.edu/kbase/crop/type/lamenia.htm.

Martin Kessing, JL & Mau, RFL 2007a, *Abgrallaspis cyanophylli (Signoret)*, Crop Knowledge Master, available at http://www.extento.hawaii.edu/Kbase/Crop/crop.htm.

-- -- 2007b, *Dysmicoccus neobrevipes (Beardsley)*, Crop Knowledge Master, available at www.extento.hawaii.edu/kbase/crop/Type/d_neobre.htm.

May, TW, Milne, J, Shingles, S & Jones, RH 2003, *Fungi of Australia vol. 2B: catalogue and bibliography of Australian fungi 2. Basidiomycota p.p. & Myxomycota p.p*, Grgurinovic, CA & Cayzer, L (eds), Australian Biological Resources Study/Commonwealth Scientific and Industrial Research Organisation, Melbourne.

McKenzie, E 2014, 'Plant associated fungi from Nauru, South Pacific', *Plant Pathology & Quarantine*, vol. 4, pp. 18-21.

Miller, DR & Davidson, JA 2005, *Armored scale insect pests of trees and shrubs (Hemiptera: Diaspididae)*, Cornell University Press, Ithaca & London.

Morton, JF 1987, *Fruits of warm climates*, Dowling, CF (ed), Florida Flair Books, Miami, Florida, USA.

Muir, F 1927, 'Hemiptera: Fulgoroidea', *Insects of Samoa and other Samoan terrestrial Arthropoda*, vol. 1, no. 1, pp. 1-27.

Nafus, D 1997, *An insect survey of the Federated States of Micronesia and Palau*, Technical paper No. 210, South Pacific Commission, Noumea, New Caledonia.

NSWDPI 2017, 'Family Derbidae - Derbid planthoppers', available at www.dpi.nsw.gov.au/keys/fulgor/derbidae/derbidae.htm.

NWC 2005, '*A manual for the growing and marketing of breadfruit for export*', Nature's Way Cooperative (Fiji) Ltd.

Pont, A 2016, 'Family Muscidae',in *Catalog of the Diptera of the Australasian and Oceanian Regions (online version)*, Evenhuis, N (ed).

Poole, M 2010, *An annotated catalogue of insects and allied species associated with Western Australian agriculture and related industries*, Perennial draft, July 2010, Department of Agriculture and Food, Western Australia.

Poole, MC 2005, *Green coffee scale Coccus viridis (Green) [Hemiptera: Coccidae]*, Farmnote 16/2005, Department of Agriculture, Western Australia.

Pullen, K, Jennings, D & Oberprieler, R 2014, 'Annotated catalogue of Australian weevils (Coleoptera: Curculionoidea)', *Zootaxa*, vol. 3896, pp. 1–481.

Purea, M, Putoa, R & Munro, E 1997, 'Fauna of Fruit Flies in Cook Islands and French Polynesia', *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji 28–31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 54–7.

QDAF 2012, 'Cryptic mealybug', *A-Z list of horticultural insect pests*, Queensland Government Department of Agriculture and Fisheries, Brisbane, available at www.daf.qld.gov.au/plants/fruit-and-vegetables/a-z-list-of-horticultural-insect-pests/cryptic-mealybug

Qin, TK & Gullan, PJ 1994, 'Taxonomy of the wax scales (Hemiptera: Coccidae: *Ceroplastinae*) in Australia', *Invertebrate Taxonomy*, vol. 8, no. 4, pp. 923-59.

Ragone, D 1997, *Breadfruit Artocarpus altilis (Parkinson) Fosberg.* , Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy.

-- -- 2006, ‘*Artocarpus altilis* (Breadfruit)’, in *Traditional trees of Pacific Islands: their culture, environment and use*, Elevitch, C (ed), Permanent Agriculture Resources (PAR), Holualoa, Hawaii.

-- -- 2011, ‘Farm and forestry production and marketing profile for breadfruit (*Artocarpus altilis*)’, in *Specialty crops for Pacific Island Agroforestry*, Elevitch, C (ed), Permanent Agriculture Resources (PAR), Holualoa, Hawai’i, USA.

Sampson, PJ & Walker, J 1982, *An annotated list of plant diseases in Tasmania*, Department of Agriculture, Tasmania.

Sangchote, S, Wright, J & Johnson, G 2003, ‘Diseases of breadfruit, jackfruit and related fruit crops’, in *Diseases of tropical fruit crops*, Ploetz, R (ed), CAB International, Wallingford, United Kingdom.

Secretariat of the Pacific Community 2019, ‘Pacific Islands Pest List Database (PLD)’, available at http://www.spc.int/pld/, accessed 2019.

Shivas, RG 1989, ‘Fungal and bacterial diseases of plants in Western Australia’, *Journal of the Royal Society of Western Australia*, vol. 72, no. 1-2, pp. 1-62.

Simmonds, JH 1966, *Host index of plant diseases in Queensland*, Department of Primary Industries, Brisbane.

Smith, D, Beattie, GAC & Broadley, RH 1997, *Citrus pests and their natural enemies: intergrated pest management in Australia*, Queensland Department of Primary Industries, Brisbane.

Stocks, I & Roda, A 2011, ‘The Passionvine Mealybug, *Planococcus minor* (Maskell), a new exotic mealybug in South Florida (Hemiptera: Pseudococcidae)’, *Pest alert DACS-P-01769,* , Florida Department of Agriculture and Consumer Services, Division of Plant Industry, available at.

Stout, OO 1982, *Plant quarantine guidelines for movement of selected commodities in the Pacific: UNDP/FAO-Spec survey of agricultural pests and diseases in the South Pacific*, New Zealand Ministry of Agriculture and Fisheries, Wellington.

Symonds, M, Moussalli, A & Elgar, M 2009, ‘The evolution of sex pheromones in an ecologically diverse genus of flies’, *Biological Journal of the Linnean Society*, vol. 97, pp. 594–603.

Tiseli, VT 2009, *Utilisation of the HTFA facility to expand the export of fresh fruits and vegetables from Tonga to New Zealand: a value chain approach*, Food and Agriculture Organization of the United Nations, Sub-regional office for the Pacific Islands.

Tora Vueti, E, Ralulu, L, Walker, G, Allwood, A, Leweniqila, L & Balawakula, A 1997, ‘Host availability – its impact on seasonal abundance of fruit flies’, *Management of fruit flies in the Pacific. A regional symposium, Nadi, Fiji 28-31 October 1996*, Australian Centre for International Agricultural Research, Canberra, pp. 105-10.

Tunupopo, F, Enosa, B, Peters, A & Tora Vueti, E 2002, ‘*Fruit flies in Samoa*’,in *Pest advisory leaflet*, Secretariat of the Pacific Community.

Tupou, S, Heimoana, V, Foliaki, S & Tora Vueti, E 2001, *Fruit flies in Tonga*, Pest Advisory Leaflet No. 41, Plant Protection Service, Secretatiat of the Pacific Community, available at https://lrd.spc.int/spcgiz-qclimate-protection-through-forest-conservation-in-the-pacific-islandsq/studies-and-reports/doc_download/2175-pal-41-fruit-flies-tonga-en.

Vargas, R, Piñero, J & Leblanc, L 2015, ‘An overview of pest species of *Bactrocera* fruit flies (Diptera: Tephritidae) and the integration of biopesticides with other biological approaches for their management with a focus on the Pacific region’, *Insects*, vol. 6, pp. 297-318.

Venette, RC & Davis, EE 2004, *Mini risk assessment: passionvine mealybug: Planococcus minor (Maskell) [Pseudococcidae: Hemiptera]*, University of Minnesota, St Paul, Minnesota, available at http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/downloads/pra/pminorpra.pdf (pdf 7.31 mb).

Wardlaw, T, Lawson, S, Wylie, R, Griffiths, M, King, J, Bashford, D, Lal, S & Tumukon, T 2012, *Establishing pest detection systems in South Pacific countries and Australia*, Australian Centre for International Agricultural Research, Canberra.

Waterhouse, D 1993, *Biological control: Pacific prospects – Supplement 2*, Australian Centre for International Agricultural Research, Canberra.

Waterhouse, DF & Norris, KR 1987, *Biological control : Pacific prospects*, Australian Centre for International Agricultural Research, Canberra.

Watson, G 2017, 'Diaspididae of the World',in *Arthropods of economic significance*, Ulenberg, S (ed).

Wheeler, AG, Jnr 2000, 'Plants bugs (Miridae) as plant pests', in *Heteroptera of economic importance*, Schaefer, CW & Panizzi, AR (eds), Cooperative Research Centre Press, Boca Raton.

White, IM & Elson-Harris, MM 1994, *Fruit flies of economic significance: their identification and bionomics*, CAB International and ACIAR, Wallingford, UK.

Williams, DJ & Watson, GW 1988a, *The scale insects of the tropical South Pacific region: part 1. The armoured scales (Diaspididae)*, CAB International, Wallingford.

-- -- 1988b, *The scale insects of the tropical South Pacific region: part 2. The mealybugs (Pseudococcidae)*, CAB International, Wallingford.

-- -- 1990, *The scale insects of the tropical South Pacific region: part 3. The soft scales (Coccidae) and other families*, CAB International, Wallingford.

Wilson, M 2009, 'A checklist of Fiji Auchenorrhyncha (Hemiptera) - Fiji Arthropods XII', *Bishop Museum Occasional Papers*, vol. 102, pp. 33-48.

Wood, S 1960, 'Coleoptera: Platypodidae and Scolytidae', *Insects of Micronesia*, vol. 18, pp. 1–74.

WTO 1995, *Agreement on the application of sanitary and phytosanitary measures*, World Trade Organization, Geneva, available at https://www.wto.org/english/docs_e/legal_e/15-sps.pdf (pdf 90.58 kb).

Zerega, N, Ragone, D & Motley, T 2004, 'Complex origins of breadfruit (*Artocarpus altilis*, Moraceae): Implications for human migrations in Oceania', *American Journal of Botany* vol. 91, pp. 760-6.